U.S. Department
of Transportation

United States
Coast Guard

Commandant
United States Coast Guard

2100 Second Street, S.W.
Washington, DC 20593-0001
(202) 267-0990

COMDTINST M16562.4A
MAY 18 1994

COMMANDANT INSTRUCTION M16562.4A

Subj: Specification of the Transmitted Loran-C Signal

1. PURPOSE. This Loran-C specification is intended as a reference document consisting of definitions, specifications, and explanations for general distribution to designers, manufacturers, and users. This specification provides a technical description of the transmitted Loran-C signal. The appendices provide additional data about each Loran-C chain together with diagrams that geographically show the signal coverage and geometric accuracy.

2. ACTION. Loran-C Regional Managers shall ensure compliance with this instruction.

3. DIRECTIVES AFFECTED. Commandant Instruction M16562.4 is cancelled. In the event of discrepancies between this specification and the Aids to Navigation Manual, Radionavigation (COMDTINST M16500.13), COMDTINST M16500.13 shall take precedence.

4. SUMMARY OF MAJOR CHANGES. All appendices have been updated to reflect current U.S. Coast Guard and Canadian Loran-C stations and chains as of 1 Jan 1995. Appendix D has been added to show points of contact for the Loran-C system.

5. REQUIRED REPORTS. None.

/s/ W. J. ECKER
Chief, Office of Navigation Safety
and Waterway Services

SPECIFICATION OF THE LORAN-C SIGNAL

TABLE OF CONTENTS

This page intentionally left blank.

SPECIFICATION OF THE TRANSMITTED LORAN-C SIGNAL

CHAPTER 1 - INTRODUCTION

A. Purpose

This Loran-C specification is intended as a reference document consisting of definitions, specifications, and explanations for general distribution to designers, manufacturers, and users. This specification provides a technical description of the Loran-C transmitting station's signal.

B. Scope

The Loran-C Radionavigation System, managed by the U.S. Coast Guard, is the federally provided radionavigation system for civil marine use in the U.S. coastal waters. It is also designated by the Federal Aviation Administration (FAA) as a supplementary system in the National Airspace System (NAS). This system provides accurate radionavigation and timing services to users in the United States of America and Canada. Loran-C is also being used and developed by several other countries in Europe and Asia.

Estimates of Loran-C system accuracy must take into consideration the transmitted signal, signal propagation, signal reception, interference or errors from outside sources such as natural and man-made electromagnetic noise, skywave contamination, geometric dilution of precision, other Loran-C signals, communication information superimposed on the navigation signal, and coordinate conversion. This specification addresses only the transmitted signal (without Loran-C communications modulation) and its control. Chapter 3 provides information on calibration and data collection procedures that affect system accuracy.

The transmitted pulses from all U.S. and Canadian operated Loran-C chains satisfy the requirements of this specification. Due to equipment limitations or the requirement for dual-rate operation, two compliance code categories have been established. In general, Category 2 specifications apply only to older equipment while Category 1 specifications apply to the newer equipment. Transmitted test or experimental signals are not within the scope of this document. It is assumed that the reader of this specification has a knowledge of the fundamentals of the Loran-C Radionavigation System.

This page intentionally left blank.

CHAPTER 2 - LORAN-C TRANSMISSIONS

A. Transmitted Pulse

All specifications listed herein are defined in terms of the current waveform at the base of the transmitting antenna.

1. Pulse Leading Edge

Each station transmits signals which have standard pulse leading-edge characteristics. Each pulse consists of a 100 kHz carrier that rapidly increases in amplitude in a prescribed manner and then decays at a rate which depends upon the particular transmitter and antenna characteristics. The leading edge of the standard Loran-C pulse waveform, against which the actual antenna current waveform is compared, is defined as i(t), where

$$i(t) = 0 \; ; \; \text{for } t < \tau \qquad (2.1)$$

$$i(t) = A(t-\tau)^2 \exp\left[\frac{-2(t-\tau)}{65}\right] \text{SIN}\,(0.2\pi t + PC) \; ; \; \text{for } \tau \le t \le 65 + \tau \qquad (2.2)$$

Pulse Leading Edge Formula.

where:

A is a normalization constant related to the magnitude of the peak antenna current in amperes.
t is time measured in microseconds.
tau is the envelope-to-cycle difference (ECD) in microseconds. The range is -5 < tau < +5 usec.
PC is the phase-code parameter (in radians) which is 0 for positive phase code and pi for negative phase code.

Note in equations 2.1 and 2.2 that the first half-cycle of antenna current is 5 microseconds or shorter. When the ECD is positive, the first half-cycle commences at time tau and ends at time t = 5 microseconds, for a length of 5-tau microseconds. When the ECD is negative, the pulse theoretically begins before time (t) = 0, at time (t) = tau. The energy in this interval, however, is usually too small to be measured and does not constitute a half-cycle. Therefore, the first half-cycle begins at time t = 0 and ends at time t = 5 when the ECD is negative. Because of the difficulties of measuring and shaping the beginning of the antenna current pulse, these specifications allow a greater tolerance over the first few half-cycles.

Note that the principal transformation which occurs between the antenna current and far E-field is a 90 carrier phase shift and a resultant change in the ECD (tau) by approximately 2.5 microseconds. See Chapter 4 for a mathematical description of this transformation.

a. Envelope-to-Cycle Difference (ECD)
The ECD of an actual Loran-C pulse is determined in the following manner:

(1) The deviation between the actual waveform, sampled at the first eight half-cycle peaks, and the standard leading edge (equation 2.2) is computed.

(2) This deviation is minimized in a root-sum-square sense over ECD and the first 40 microseconds.

(3) The ECD of the pulse is that value which minimizes this deviation.

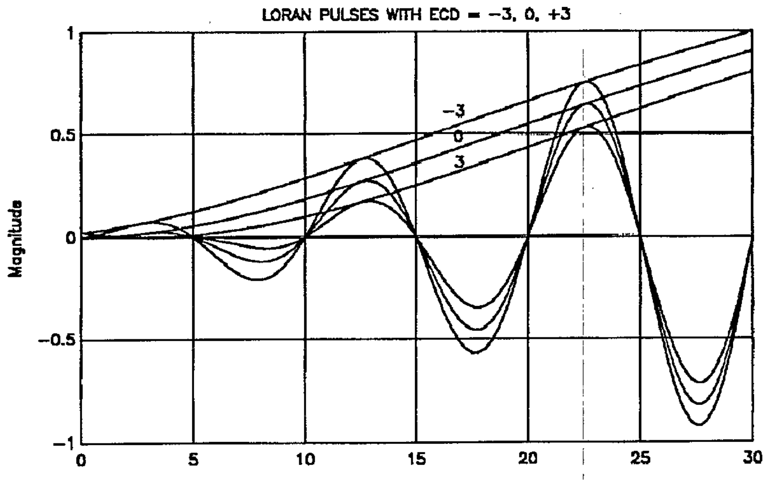
(4) The following empirical relationship for an all-seawater path is used to determine the best Nominal ECD for a transmitting station:

$$\mathbf{ECD = 2.5 + NECD - 0.0025d}$$

where:

NECD = nominal ECD of transmitting station
(as defined in Chapter 4)
d = distance in nautical miles from the transmitting station

(5) Figure 1 shows the first six half-cycles of loran pulses with ECDs of -3, 0 and +3 microseconds. The theoretical envelope of each pulse is superimposed. These envelopes are exactly 3 microseconds apart along the horizontal scale.



Elapsed Time, microseconds

b. <u>Half-Cycle-Peak Amplitudes (Ensemble Tolerance)</u>
For any ECD in the range -2.5 to +2.5 microseconds, the ensemble of the peak amplitudes of the first eight half-cycles of the first pulse of each group meets the following criterion:

$$\left[\frac{\sum_{N=1}^{N=8}(I_N - S_N)^2}{8}\right]^{1/2} \leqslant .01 \qquad (2.3)$$

Half-Cycle-Peak Amplitudes.

where:

I(N) and S(N) are normalized samples of the Nth half-cycle peaks of the standard and actual, respectively, antenna current waveforms.

The ensembles I(N) and S(N) are generated in the following manner:

(1) The ECD and pulse peak amplitude estimates are determined in accordance with Chapter 2.A.1.a above.

(2) Based upon this ECD and pulse peak amplitude, an ensemble of standard half-cycle peak samples (I(N)), normalized to the pulse peak, is calculated using equation (2.2).

(3) The eight half-cycle peak samples of the actual waveform are normalized to this pulse peak to produce the ensemble S(N).

c. Half-Cycle Peak Amplitudes (Individual Tolerances)
The peak amplitude of each half-cycle of the first antenna-current pulse for each group meets the following criteria:

$$|I_N - S_N| \leq .03 \qquad 1 \leq N \leq 8 \qquad (2.4)$$

$$|I_N - S_N| \leq .10 \qquad 9 \leq N \leq 13 \qquad (2.5)$$

Half-Cycle-Peak Amplitudes.

where
I(N) and S(N) are defined in Chapter 2.A.1.b above.

2. Pulse Trailing Edge
The pulse trailing edge (that portion of the Loran-C pulse following the peak of the pulse or 65 microseconds, whichever occurs first) is controlled in order to maintain spectrum requirements. At different transmitting sites, or with different transmitting equipments, the pulse trailing edge may differ significantly in appearance and characteristics. Regardless of these differences, for each pulse and for all t>500 microseconds, i(t) satisfies the criteria of Table 1.

Category 1 : $i(t) \leq .0014\,A$
Category 2 : $i(t) \leq .016\,A$

Table 1 – PULSE TRAILING EDGE TOLERANCES BASED UPON PEAK AMPLITUDE (A).

Pulse Trailing Edge Tolerances Based Upon Peak Amplitude (A).

3. <u>Zero-Crossing Times and Tolerances within a Pulse</u>
A standard Loran-C pulse (positive phase code and ECD = 0) is shown in Figure 2 with half-cycles and zero crossings of interest identified. Zero-crossing times are measured with respect to the standard zero crossing (the positive going zero crossing at 30 microseconds for a positively phase coded pulse). With ECDs in the range of -2.5 to 2.5 microseconds, zero-crossing times and tolerances of the first pulse are shown in Table 2. See Chapter 2.B.5.c for the specifications regarding the conformance of other pulses in the group to this first pulse.

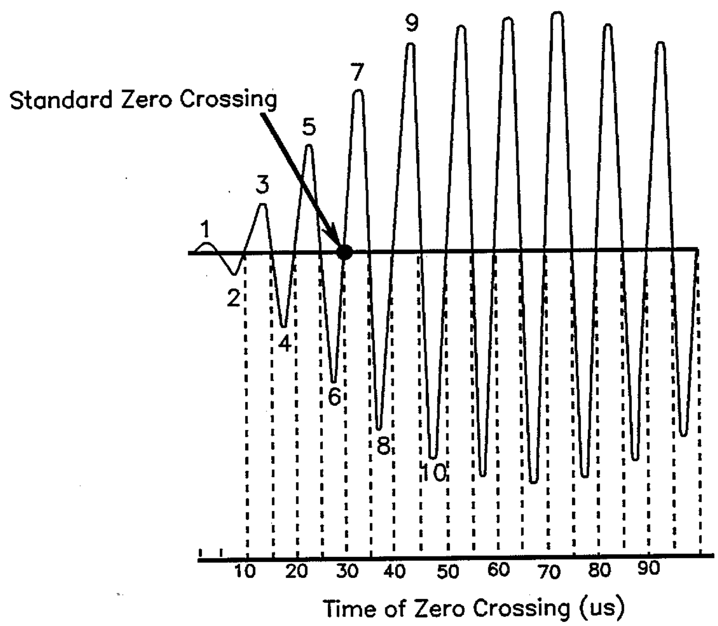


FIGURE 2 - Zero-crossing times and labels for half-cycles. This figure illustrates a positive pulse. For a negative pulse, only the polarity changes, but the labels remain the same.

Zero Crossing (us)	Time (us)	Tolerance (ns)	
		Category 1	Category 2
5	−25	±1000	±2000
10	−20	±100	±1500
15	−15	±75	±1000
20	−10	±50	±500
25	−5	±50	±250
30	Standard zero crossing	(Time	Reference)
35	5	±50	±100
40	10	±50	±100
45	15	±50	±100
50	20	±50	±100
55	25	±50	±100
60	30	±50	±100

Beyond 60 us the zero crossings conform to 100kHz + 1kHz

TABLE 2 – ZERO–CROSSING TIMES (WITH RESPECT TO THE STANDARD ZERO CROSSING) AND TOLERANCES.

B. Pulse Groups

1. Group Repetition Interval (GRI)

Each Loran-C station operates with a specified GRI. As published in the Federal Register Volume 40, Number 29 of 11 February 1975, permissible GRIs are multiples of 10 microseconds from 40000 through 99990 microseconds. The identifier of the GRI is the GRI code, which is defined as the GRI in microseconds divided by 10 (i.e., 7980 to define a GRI of 79,800 microseconds).

2. Timing of Master Pulse Group

The 1987 amendment to Public law 100-223, 1982 Airport and Airway Improvement Act, requires that all master Loran-C transmitting stations subject to U.S. jurisdiction be synchronized to within approximately 100 nsec of Coordinated Universal Time (UTC). Since 1989, the U.S. Coast Guard has been working in conjunction with the US Naval Observatory (USNO) to achieve this somewhat ambiguous goal. At the time of printing, the standard zero crossing of the first master pulse of Group A is normally synchronized to within 500 nsec of the UTC second. By improving administrative control methods, master station offsets of 200 nsec can be achieved. Various other methods are being studied in order to fulfill the requirements of public law. Because the GRI's of chains differ, it is necessary to relate the timing of all master stations to a common epoch. This epoch is 0 hr, 0 min, 0 sec, 1 January 1958. The expected Times-of-Coincidence (TOC) of a master station's transmissions with the UTC second are published in the Times of Coincidence, Null Ephemeris Tables, Series 9 developed by and available from USNO. The difference between the time of the master's transmission with respect to UTC is also published by USNO in the Series 4 and Series 100 Bulletins. USNO Time Service Information letter of 15 August 1973, provides guidelines for making time measurements.

3. Timing of Secondary Pulse Groups

Secondary pulse groups are transmitted with the same GRI as the master pulse group and are linked in time to the master. The emission delays of secondary stations with respect to the master are selected to ensure that the following criteria are met within each chain wherever the signals can be received:

a. The minimum time difference between any secondary and master is 10,900 microseconds.

b. The minimum difference of any two time differences is 9,900 microseconds.

c. The maximum time difference is the Group Repetition Interval minus 9,900 microseconds.

d. The minimum spacing between corresponding points of the last pulse of any station's group and the first pulse of the next group in the same chain is 2900 microseconds, except that the minimum spacing between the master's ninth pulse and the next secondary pulse (of the same chain) may be as little as 1900 microseconds. (This is a direct result of applying the first three criteria.)

Figure 3 is provided as an aid to understanding these criteria. In general, emission delays are kept as small as possible to allow the use of the smallest GRI. Tolerances on the synchronization of secondary station transmissions with respect to master transmissions may vary from chain to chain. See Chapter 3.B for chain control procedures and Chapter 3.C for Loran-C chain details.

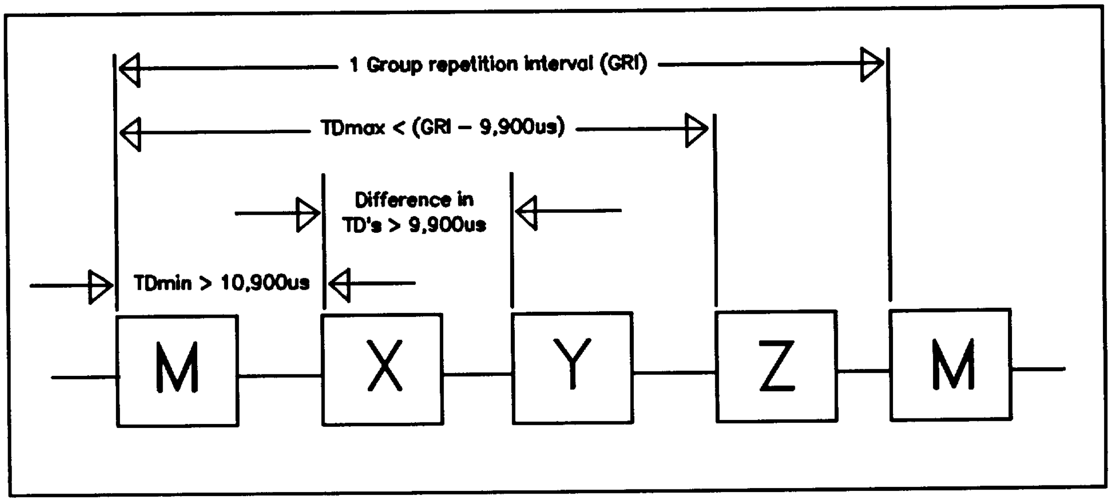


Figure 3 - Constraints for assignment of emission delay

4. Pulse-Group Phase Coding
   Each Loran-C station transmits groups of phase-coded pulses in conformance with Table 3. For identification, the first group of pulses in the transmission sequence is labeled Group A and the second group, one GRI later, is labeled Group B. A transmission sequence (called phase-code interval (PCI) encompasses both Group A and Group B; thereafter, the I9533*IMAGES:

	Station	
Group	Master	Secondary
A	++−−+−+−+	+++++−−+
B	+−−++++++−	+−+−++−−

TABLE 3 — LORAN-C PHASE CODES

5. Uniformity of Pulses within Pulse Group
   The uniformity of pulses within a pulse group depends not only on what equipment is in use, but also on whether or not the station is single-rated (SR) or dual-rated (DR).

a. <u>Pulse-to-Pulse Amplitude Tolerance</u>
When compared using Equation (2.6), the amplitude of the smallest pulse in a group does not differ from the amplitude of the largest pulse in the same group by more than the limits specified in Table 4.

$$D = \%\,\text{Droop} = \left[\frac{I_{pk}(\text{Max}) - I_{pk}(\text{Min})}{I_{pk}(\text{Max})}\right] \times 100 \qquad (2.6)$$

Equation 2.6

where

I(pk)Max is the value of i(t) at the peak of the largest pulse.

I(pk)Min is the value of i(t) at the peak of the smallest pulse.

	Category	Category 2
Single Rate	5 %	10 %
Dual Rate	10 %	20 %

TABLE 4 — PULSE—TO—PULSE AMPLITUDE TOLERANCE, OR PERCENT DROOP (D).

b. <u>Pulse-to-Pulse ECD Tolerance</u>
The pulse-to-pulse ECD tolerance accounts for the pulse-to-pulse leading-edge differences (Chapter 2.A.1) and the pulse-to-pulse zero-crossing differences (Chapter 2.A.3). The ECD of any single antenna-current pulse does not differ from the average ECD of all pulses contained in both Group A and Group B by more than the values given in Table 5.

	Category 1	Category 2
Single Rate	0.5 us	1.0 us
Dual Rate	0.7 us	1.5 us

TABLE 5 – PULSE–TO–PULSE ECD TOLERANCES.

c. Pulse-to-Pulse Timing Tolerance

Pulses two through eight of a group are referenced in time to the first pulse of each group. The timing relationship and tolerances of the standard zero crossings of pulses two through eight with respect to the standard zero crossing of pulse one are indicated in Table 6 below. Due to design limitations, Category 2 transmitters may also exhibit a small fixed offset (C) on negatively phase coded pulses.

	Category 1	Category 2
Single Rate	(N–1) 1000 us $\pm$ 25 ns	(N–1) 1000 us $\pm$ 50 ns + C
Dual Rate	(N–1) 1000 us $\pm$ 50 ns	(N–1) 1000 us $\pm$ 100 ns + C

N is the pulse number (2 thru 8) of the pulses which follow the first pulse within each group. C is 0 for positively phase coded pulses; $|C| \leq$ 150 ns for negatively phase coded pulses. The standard zero crossing of pulse one is the time reference within each group.

TABLE 6 – PULSE–TO–PULSE TIMING TOLERANCES.

The ninth pulse of a master signal group is spaced 2000 microseconds from the eighth pulse of the group. This pulse is used primarily as a visual aid to master group identification and not for navigation.

C. Blink

Blink is a repetitive on-off pattern (approximately 0.25 second on, 3.75 seconds off) of the first two pulses of the secondary signal which indicates that the baseline is unusable for one of the following reasons:

- TD out of tolerance
- ECD out of tolerance
- Improper phase code or GRI
- Master or secondary station operating at less than one half of specified output power.

Blink continues until the out-of-tolerance condition is eliminated.

The ninth pulse of the master signal can also be blinked, but master blink is not an indicator of out of tolerance. Master blink is used only for internal Loran-C system communications. If used, the master's ninth pulse will be blinked in accordance with the code shown in Figure 4. There is no ninth pulse blink sequence defined for victor secondaries. For master ninth pulse blink purposes only, victor secondaries are co-designated as whiskey secondaries. The master ninth pulse blink receiving equipment at each secondary can be remotely disabled allowing communications with either the whiskey or the victor secondary.

D. Two-Pulse Communications

Two-Pulse Communication (TPC) is a synchronous communication system which uses two Loran-C pulses to transmit information. Pulse position modulation is used on the seventh and eighth pulses. A balanced modulation code is used to ensure that the transmission of a TPC message does not cause gross offsets in a Loran-C receiver. Each pulse is advanced and retarded once in each Phase Code Interval (PCI); therefore the net change of position for each pulse is zero.

Synchronization (sync) bits are essential since TPC uses synchronous transmission. Sync bits reset the timing chain and define the next PCI as the first PCI of a new character. Sync bits are not sent when data is being transmitted. They are only sent during the last PCI of the programmed sync interval. The sync interval can be either 4, 8, 12, or 16 character periods. Sync bits are distinguished from data bits by the amount they are modulated (2.4 usec) and by the transmission code.

Data bits (either 0 or 1) are determined by advancing or retarding the pulses by 1 usec according to table 7. It requires one PCI to transmit one bit once. Data bits may be sent between 1 and 16 times as determined by the operators.

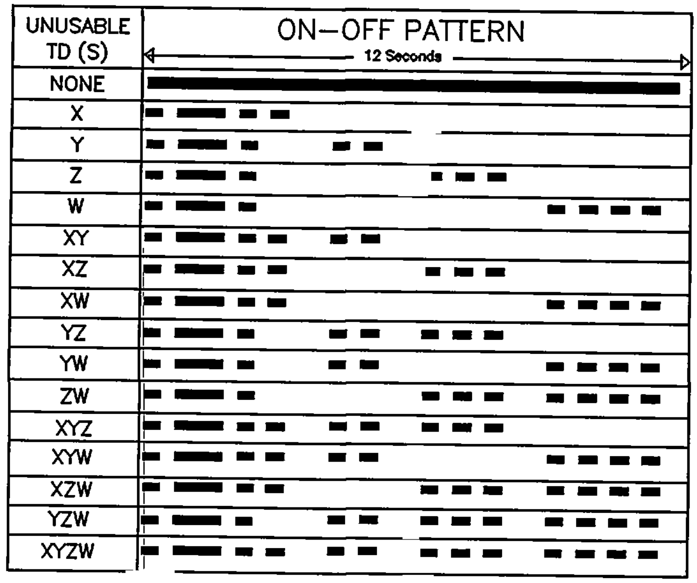


Figure 4 Master ninth pulse blink codes.

▬ approximately 0 25 seconds on
▬▬ approximately 0 75 seconds on

BIT TYPE	MODULATED AMOUNT +/-	GRI A FIRST PULSE	GRI A SECOND PULSE	GRI B FIRST PULSE	GRI B SECOND PULSE
DATA 1	1 usec	ADVANCE	RETARD	RETARD	ADVANCE
DATA 0	1 usec	RETARD	ADVANCE	ADVANCE	RETARD
SYNC	2.4 usec	ADVANCE	ADVANCE	RETARD	RETARD

Table 7 Balanced code transmission format

E. Dual-Rate Blanking

To provide contiguous service from one chain to the next, some stations are operated as members of two chains and radiate signals on two GRIs. Such stations are periodically faced with the impossible requirement of radiating overlapping pulse groups simultaneously. During the time of overlap, those pulses of one group which overlap any part of the other group's blanking interval are blanked or suppressed. The blanking interval for stations equipped with vacuum tube transmitters extends from 500 microseconds preceding the first pulse of the group to 1400 microseconds following the last pulse. The blanking interval for stations equipped with the new solid state transmitters (AN/FPN-64) is slightly longer, from 900 microseconds before the first pulse to 1600 microseconds after the last.
Blanking is accomplished in one of two ways: priority blanking or alternate blanking. In priority blanking, the same rate is always blanked at every overlap; the priority rate (never blanked) is generally selected to be the rate with the longest GRI. In alternate blanking, the priority role is time-shared between the two rates; the time-sharing period is set at four GRIs of one rate, generally the one with the longer GRI. (Note, alternate blanking may also be called "Alternate PCI Blanking".) The chain data sheets in appendix (A) identify which type of blanking is in use.

F. Signal Availability

The goal is 99.9% signal availability for each transmitting station and 99.7% for each triad, computed on an approximately monthly basis, including authorized off-air time. A baseline is considered not available when any of the following conditions exist:

a. TD out of tolerance
b. ECD out of tolerance
c. Improper phase code or GRI
d. Master or secondary station off-air or operating at less than one half of specified output power.

Routine equipment change-overs which are accomplished with no more than a 60 second suspension of Loran-C transmissions are considered as continuous transmissions.

G. Spectrum

The total energy outside the 90-110 kHz band shall be less than 1% of the total radiated energy. The energy below 90 kHz shall be no greater than 0.5% and the energy above 110 kHz shall be no greater than 0.5% of the total radiated energy.

H. Loran-C Transmitting Station Compliance Requirements

All U.S. and Canadian controlled Loran-C chains must meet the following Specifications:

Pulse Leading Edge (Chapter 2A1)
Group Repetition Interval (Chapter 2B1)
Timing of Master Pulse Group (Chapter 2B2)
Timing of Secondary Pulse Groups (Chapter 2B3)
Pulse Group Phase Coding (Chapter 2B4)
Blink (Chapter 2C)
Dual Rate Blanking (Chapter 2E)
Signal Availability (Chapter 2F)
Spectrum (Chapter 2G)

Due to differing equipment capabilities and local idiosyncrasies, the following specifications allow for Category 1 or Category 2 compliance:

Pulse Trailing Edge (Chapter 2A2)
Pulse Zero Crossings (Chapter 2A3)
Uniformity of Pulses (Chapter 2B5)

Table 8 is a station-by-station listing of the compliance requirements for these particular specifications.

Station	(Ant) XMTR	Rate	Compliance Requirements Categories				
			Pulse Trailing Edge (2.A.2)	Pulse Zero Crossings (2.A.3)	Uniformity of Pulses (2 B 5)		
					Amplitude (2 B 5 a)	ECD (2 B 5 b)	Timing (2 B 5 c)
ST PAUL, AK	(625) 42/44**	9990	2	2/1	2/1	2/1	2/1
ATTU, AK	(625) 44	9990/5980	2	1	1	1	1
PORT CLARENCE,AK	(1350) 42/44**	9990/7960	1	2/1	2/1	2/1	2/1
KODIAK, AK	(625) 44	9990/7960	2	2	1	2	1
TOK, AK	(SLT) 44	7960	1	1	1	1	1
SHOAL COVE, AK	(SLT) 44	7960/5990	1	1	1	1	1
WILLIAMS LAKE, BC	(625) 44	5990/8290	2	1	1	1	1
GEORGE, WA	(SLT) 45	5990/9940	1	1	1	2	1
PORT HARDY, BC	(625) 64	5990	1	1	1	1	1
FALLON, NV	(625) 44	9940	2	1	1	1	1
MIDDLETOWN, CA	(625) 44	9940	2	1	1	1	1
SEARCHLIGHT, NV	(SLT) 44	9940/9610	1	1	1	1	1
MALONE, FL	(700) 64	8970/7980	1	1	1	1	1
GRANGEVILLE, LA	(700) 64	7980/9610	1	1	1	1	1
RAYMONDVILLE, TX	(700) 64	7980/9610	1	1	1	1	1
JUPITER, FL	(625) 64	7980	1	1	1	1	1
CAROLINA BEACH, NC	(TIP) 64	9960/7980	1	1	1	1	1
SENECA, NY	(700) 64	9960/8970	1	1	1	1	1
CARIBOU, ME	(SLT) 64	9960/5930	1	1	1	1	1
NANTUCKET, MA	(625) 64	9960/5930	1	1	1	1	1
DANA, IN	(625) 44	9960/8970	2	2	1	2	1
BAUDETTE, MN	(720) 64	8970/8290	1	1	1	1	1
CAPE RACE, NFLND	(850) 64	5930/7270	1	1	1	1	1
FOX HARBOUR, LABR	(700) 64	5930/7270	2	1	1	1	1
BOISE CITY, OK	(700) 64	8970/9610	1	1	1	1	1
GILLETTE, WY	(700) 64	8290/9610	1	1	1	1	1
LAS CRUCES, NM	(700) 64	9610	1	1	1	1	1
HAVRE,MT	(700) 64	8290	1	1	1	1	1
COMFORT COVE, NFLND*	(625) 64	7270	1	1	1	1	1

Station Compliance Requirements

This page intentionally left blank.

CHAPTER 3 - LORAN-C SYSTEM INFORMATION

This chapter is intended not as a binding specification on Loran-C transmissions, but as an information document on the many details which relate to Loran-C calibration, Loran-C control procedures and Loran-C services from the various chains.

A. System Calibration Procedures:

1. Discussion

The primary purpose of a Loran-C chain calibration is to ensure that the Emission Delay (ED) of each secondary station is set to the value published by the U.S. Coast Guard. This is accomplished using an equipment suite which directly measures the Time of Transmission (TOT) of each station in the chain. The ED is then calculated using the procedures discussed in Chapter 3.A.3.b. During the calibration, the approximate UTC position of the master's transmission in time is determined and a crude UTC synchronization can be achieved.

2. Equipment

The time standard for the ED equipment suite (designated the Emission Delay Measurement Equipment Suite) is a Hewlett-Packard Model 5061A Cesium Beam Frequency Standard with option 001 Time Standard. This device is used with a Hewlett-Packard Model K02-5060A Standby Power Supply making it a portable "Hot Clock". The 5 MHZ signal from the standard is used (with a rate generator) to generate a reference Group Repetition Interval (GRI) for the ED measurements. The 1 PPS from the standard is used to synchronize the reference GRI to its UTC Time of Coincidence (TOC). The reference GRI is the time standard against which all TOT measurements are made. TOC is defined as the UT second where the standard zero crossing of the master station's first pulse (phase code group A) is coincident with the occurrence of the UT second. The TOT measurements are made with respect to the Standard Zero Crossing, (SZC), 30 microseconds after the beginning of the pulse.

The antenna current waveform is sensed by a clamp-on, current transformer installed on the transmitting antenna ground return line. The transformer is marked to ensure correct phasing of its output. The actual TOT measurement is made using a Hewlett-Packard Model 5360 or 5370 Time Interval Counter (there are two systems in use). These units measure the time difference between the beginning of the reference GRI and the SZC on the transmitting antenna current pulse. The TOTs for all sixteen pulses in one phase code interval (PCI) are measured.

Auxiliary equipment included in the suite perform common mode interference rejection, signal attenuation, oscilloscope trigger generation, oscilloscope monitoring, and signal phase inversion (switch controlled) to permit the operator to determine the presence of and subsequently take corrective action to eliminate common mode interference within the equipment.

3. Technique

a. Data Collection

Data is collected at each secondary station once, and at the master station twice. The collection is performed at the base of the transmitting antenna. The clamp-on current transformer is installed and the signal is coupled through the common mode rejection filter to the coupler unit. The coupler unit contains the attenuator and the phase inverter. The attenuator is adjusted such that no half-cycle amplitude BEFORE the SZC exceeds the maximum input level of the Computing Counter (any half-cycle after the SZC which exceeds the input level limitation of the counter will not affect the measurement). The signal is then fed to the oscilloscope and the computing counter.

The TOC for the GRI being measured is calculated and the reference GRI is synchronized to it. A pulse corresponding to the beginning of the reference GRI is coupled to the computing counter. A Gate waveform, 10 microseconds in duration, is generated. Its delay from the start of the reference GRI is switch selectable and is positioned so it straddles the SZC of the pulse being measured. This Gate waveform is also used for oscilloscope triggering.

TOT readings (three with the inverter phasing of 0 and three with 180 phasing) are recorded for each pulse. Each TOT is the mean value of 100 separate samples of the time difference between the beginning of the reference GRI and the SZC of the pulse being measured. Then the TOT of the next pulse is measured. When completed, there will be 6 recorded mean TOTs for each pulse in phase group A and phase group B or a total of 96 TOTs.

b. Data Reduction

The purpose of the two visits to the master station is to set a start time for the calibration and to determine the frequency offset between the master operate oscillator and the "Hot Clock". The Clock Error Rate, the rate in nanoseconds per hour at which the Hot Clock 1PPS output is shifting in time with respect to that of the master operate oscillator, is calculated by measuring the timing offset between the two visits and dividing by the time from the first to the second measurement.

Using the Clock Error Rate and the period of time between the first master data collection and the data collection at the secondaries, a correction to the secondary TOTs is determined and applied. The effect of this correction is to get an actual TOT which has been corrected for "hot clock" drift.

The Controlling Standard Time Difference (CSTD) offset for the baseline, as seen at the monitor site in control of the pair, is algebraically subtracted from the secondary TOTs to correlate the measured TOT with the assigned Controlling Standard Time Differences. Then, the individual pulse TOTs for each station are adjusted (by subtracting multiples of 1 millisecond) to the first pulse of the respective phase code groups (the result of this adjustment is that all TOTs have the same milliseconds digits). The mean is taken of the adjusted TOTs yielding the final TOT for the station.

The Emission Delay of each secondary is calculated as follows:

$$\mathbf{ED(S) = TOT(S) - TOT(M)} \qquad \mathbf{(3.1)}$$

The CSTD correction is determined as

$$\mathbf{COR = ED(P) - ED(S)} \qquad \mathbf{(3.2)}$$

where
ED(P) is the published ED for the baseline. The correction is added algebraically to the presently assigned CSTD to arrive at the value for the new CSTD.

4. Chart Verification

The U.S. Coast Guard cooperates with the Defense Mapping Agency and the National Ocean Survey in the preparation and verification of Loran-C charts. The Defense Mapping Agency, with the cooperation of the USCG, prepares predicted Loran-C time differences for a given coverage area. When selected portions of the coverage area have been surveyed by the U.S. Coast Guard or National Ocean Survey, the measured points are adaptively correlated to the predicted values using force-fit techniques. This ongoing process provides feedback to ensure that predicted (charted) and measured time differences agree closely throughout the coverage area.

B. Loran-C Chain Control Procedures

1. Purpose

The purpose of Loran-C chain control is to maximize the usability of available signals within the defined service area. Therefore, a fundamental requirement of control is the measurement of selected parameters to ensure that the values established and assigned as a result of the chain calibration are maintained. The following three basic parameters are measured:

- Phase time difference (TD)
- Envelope-to-cycle difference (ECD)
- Peak radiated power

2. Procedures

The procedures utilized for control of these parameters are as specified below:

a. Phase Time Difference (TD)

Continuous measurement of the TD of each respective master-secondary pair is made at a monitor location, or locations, within the defined service area. This TD is maintained at the controlling standard time difference (CSTD) (established during the calibration) by the insertion of local phase adjustments (LPA). In general, the hourly average of TD is held to within 50 nanoseconds of the CSTD. Blink tolerances are shown on the chain data sheets of appendix (A).

b. Envelope-to-Cycle Difference (ECD)

Continuous measurements of ECD are made in the far field at the same location(s) described in 3.B.2.a above. Additionally, each transmitting station continuously measures its transmitted ECD and monitors its pulse shape through the i(t) waveform (antenna ground current). The far field Controlling Standard ECD (CSECD) and the associated Nominal ECD (NECD) at the transmitter are assigned by the program manager at the time of baseline or monitor certification. Assignment of these parameters takes into account the transmitted pulse shape and the annual cyclical propagation effects. Typically, the procedures used to assign the CSECD include a period of data collection, i.e., an average of 30 days of far-field data. During this period of data collection, the NECD is monitored to ensure it remains stable. In most cases, the NECD is maintained at 0.0 microseconds. This results in far field ECD values that ensure proper user receiver cycle selection within the prescribed coverage area. NECD assignments take into account the phase differences (+2.5 microseconds) between the antenna current waveform and the ECD observed in the far field (which is influenced in addition by the propagation path). See Chapter 4 for definitions which apply to ECD control.

c. Peak Radiated Power

Peak radiated power is monitored at each transmitting station by measurement of the zero-to-peak current in the Loran-C antenna ground return.

3. User Notification

User notification of unusable signals is accomplished by blinking initiated under the following circumstances:

- Off-air or peak radiated power less than one half of that specified
- TD out of tolerance

- ECD out of tolerance
- Improper phase code or GRI.

C. Specific Loran-C Chain Information

Specific Loran-C chain information is contained in three appendices to this document. An outline of each of the three appendices follows:

1. Loran-C Chain Data Sheets, appendix (A), contain a separate data sheet for each Loran-C chain. Each data sheet lists all Loran-C stations of a chain by name and includes the following information (where applicable): station function, location, emission delay, radiated power, control parameters (e.g., CSTD with tolerance), and other general notes of interest.

2. Predicted Loran-C Groundwave Coverage, appendix (B), contains a separate chartlet for each Loran-C chain. The predicted coverage contour for the chain is drawn on the chartlet. An explanation of the constraints and procedures used to generate the contours is provided in the introduction of appendix (B) along with a sample predicted-noise-level computation.

3. Contours which show the 2 DRMS (95%) limits with accuracies of 500, 1000, and 1500 feet are provided in appendix (C). These contours do not account for the effects of signal attenuation or noise.

This page intentionally left blank.

CHAPTER 4 - DEFINITIONS

The following definitions are provided to aid the reader in understanding this document:

A. Antenna Current: the signal at a Loran-C transmitting station taken from the transmitting antenna ground return. This waveform is used at the transmitting station to monitor and measure the Loran-C pulse.

B. Blanking (Priority, Alternate): the suppression of pulses on one rate due to the periodic phenomenon that occurs when a dual-rated transmitting station has to transmit two pulse groups of different rates at the same (or nearly the same) time. During the period of overlap, the one rate's pulses are suppressed. Priority blanking occurs when the same rate is always blanked while alternate blanking occurs when the two rates are blanked in an alternating manner. (For more information, see Chapter 2.E.)

C. Coding Delay (CD): the interval of time after reception of the master's transmission that a secondary station waits prior to transmitting its own signal. The coding delay is added to the baseline transmission delay in order to develop the Emission Delay (ED). The Coding Delays, the electrical lengths between the stations, and the lengths of the signal groups are used to develop the minimum allowed Group Repetition Interval (GRI) for a chain. The Coding Delay assigned to each secondary station allows stations of a chain to transmit sequentially in time and to prevent overlap of the different signal groups anywhere in the system.

D. Controlling Standard Envelope-to-Cycle Difference (CSECD): Envelope-to-Cycle Difference that is maintained at the monitor site as determined by chain calibration.

E. E-field Transformation: With an antenna current pulse as described in equations (2.1) and (2.2), the leading edge of the E-field Loran-C pulse as sensed outside the near far-field of the transmitting antenna is described by:

$$e(t) = 0 \; ; \; \text{for } t < \tau \qquad (4.1)$$

$$e(t) = A'(t-\tau)^2 \exp\left[\frac{-2(t-\tau)}{65}\right] \cos(0.2\pi t + PC) + \text{higher order terms}$$

$$\text{for } \tau \le t \le 65 + \tau \qquad (4.2)$$

E-Field Transformation

where

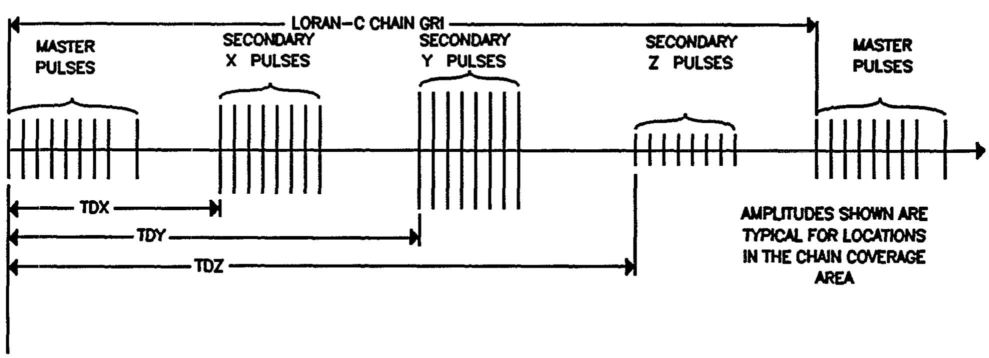
A' is a different normalization constant, t, tau, and PC are as described in equation (2.2), and the higher order terms are small and have no significant impact on the description of the leading edge of e(t) when t > 20.

F. Emission Delay: the interval of time (in microseconds) between the beginning of the first pulse from the master station and the beginning of the first pulse from the secondary station in the same chain (both stations using a common time reference). The emission delay equals the sum of the baseline travel time plus the secondary coding delay.

G. Envelope-to-Cycle Difference (ECD): ECD is the time relationship between the phase of the RF carrier and the time origin of the envelope wave form. In practice, the ECD of an actual Loran-C pulse is determined from the transmitting station antenna current waveform using the procedure in Chapter 2.A.1.a.

H. Far Field: The area typically greater than 5 to 10 wavelengths from the transmitting antenna. The far field consists of the propagating components of the electric and magnetic fields. In the far field, the term 1/R dominates in the field equations derived from Maxwell's Equations.

I. Group Repetition Interval (GRI): The time interval between successive pulse groups measured from the third cycle (or zero cross-over) of the first pulse of any one station in the group to the third cycle of the first pulse of the same station in the following pulse group. All stations in a chain have the same GRI, and the GRI expressed in tens of microseconds is the identifier for that chain and is called the chain "rate". GRI's may range from 40,000 microseconds to 99,990 microseconds, in increments of 10 microseconds.



Group Repetition Interval

J. Loran-C Peak Radiated Signal Level: The level of a Loran-C signal is the RMS level of a CW signal having the same peak-to-peak amplitude as the Loran-C pulse envelope at the peak of the pulse.

K. Near Field: The area typically within a radius of 2 wavelengths from the transmitting antenna. In this area, static and quasi-static electric and magnetic fields exist. These fields do not propagate. In the field equations derived from Maxwell's Equations, the terms 1/R and 1/R dominate.

L. Near Far-Field: the boundary area between the near and far fields typically from 2 to 10 wavelengths from the transmitting antenna. In this area, the propagating components of the electric and magnetic fields exist as in the far field but the effects of topography are not existent.

M. Nominal Envelope-to-Cycle Difference (NECD): The calculated ECD held at the transmitting station which, given the identical propagation conditions which existed during the chain calibration, would result in the assigned CSECDs being observed at the monitor sites. The Nominal ECD is determined from the transmitting station's antenna current waveform using the procedure in Chapter 2.A.1.a.

N. Phase Code Interval: That interval over which the phase code repeats itself. Loran-C phase codes repeat every two GRIs.

O. Pulse Leading Edge: The portion of the pulse between the beginning and the peak.

P. Pulse Trailing Edge: The portion of the pulse following the peak.

Q. Signal to Noise Ratio (SNR): The ratio of the RMS amplitude of the Loran pulse at the standard sampling point to the RMS value of the noise present at that time.

R. Standard Sampling Point: the point on the Loran-C pulse envelope 25 microseconds after the beginning of the pulse to which far-field field strength calculations or measurements are referenced. For the standard Loran-C pulse with 0.0 ECD, the amplitude at the standard sampling point is .506 times the peak amplitude.

S. Standard Zero Crossing: the positive zero crossing at 30 microseconds of a positively phase coded pulse on the antenna-current waveform. This zero crossing is phase-locked to the Loran-C station's cesium time reference. The standard zero crossing is used as a timing reference for measurement of Loran-C signal specifications.

T. Time Difference (TD): the interval in time between the receipt of a master station's signal and secondary station's signal from the same rate. Controlling Standard Time

Difference (CSTD) is the reference standard against which the control station compares the observations of the System Area Monitor.

U. Two-Pulse Communications (TPC): a synchronous communication system which uses two Loran-C pulses to transmit information between Loran stations. For a more complete description, see page 2-11.

APPENDIX A: LORAN-C CHAIN DATA SHEETS

TABLE OF CONTENTS

GENERAL SPECIFICATIONS

The station coordinates listed herein were furnished by the Defense Mapping Agency, Hydrographic Center and are based upon the World Geodetic System (WGS) 1984. The U.S. Coast Guard is working to synchronize all Loran-C stations to within +100 nanoseconds to UTC.

The following parameters were used in the baseline length computations:

a. **Signal propagation**: Use the velocity of light in free space as 2.99792458E8 m/s and an index of refraction of 1.000338 at the surface for standard atmosphere.

b. **Phase of the groundwave**: As defined in NBS Circular 573 (Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.)

c. **Conductivity**: Sigma = 5.0 mhos/meter (seawater). Baseline electrical distance computations were made assuming a smooth, all seawater transmission path between stations.

d. **Permittivity of the earth**: e 2 = 80 ESU (for seawater)

e. **Altitude in meters**: h 2 = 0

f. Parameter associated with the vertical lapse rate of the permittivity of the atmosphere: a = 0.75 meters

g. **Frequency**: 100kHz

h. **Spheroid**: WGS 84 (equatorial radius: a = 6378137.0 meters, polar radius: b = 6356752 meters, flattening: F = (a-b)/a = .003352811

i. **Emission Delay** = Baseline Length + Coding Delay

GENERAL NOTES

The notes below are referenced by number, where applicable, in the right-most column of each data sheet.

1. Host nation manned.

2. GCF-W-756CG Two Pulse Communications installed (Uses pulses 7 & 8 for backup control communications.)

3. Unmanned receiver site.

4. Manned receiver site.

5. Priority blanking used.

6. Alternate blanking used.

LORAN-C CHAIN DATA SHEET

CANADIAN EAST COAST LORAN-C CHAIN - GRI 5930

STATION	FUNCTION	(WGS-84) COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
CARIBOU, ME	MASTER	46 48 27.305N 67 55 37.159W		800	0.0			(6) Dual-rated to Northeast U.S. Chain (9960)
NANTUCKET, MA	XRAY	41 15 12.046N 69 58 38.536W	13131.88 11000	400	0.0			(6) Dual-rated to Northeast U.S. Chain (9960)
CAPE RACE, NEWFOUNDLAND, CANADA	YANKEE	46 46 32.286N 53 10 27.606W	28755.02 25000	500	0.0			(1),(5) Dual-rated to NFLD East Coast Chain (7270)
FOX HARBOUR, CANADA	ZULU	52 22 35.252N 55 42 27.862W	41594.59 38000	900	0.0			(1),(5) Dual-rated to NFLD East Coast Chain (7270)
LORMONSITE CAPE ELIZABETH, ME	MONITOR	43 33 54.90N 70 11 57.90W						(3)
LORMONSITE MONTAGUE,PEI, CANADA	MONITOR	46 11 40.10N 62 39 37.40W				M +1.5 X +1.1 14449.83 Y +1.1 29824.48 Z +0.9 43071.47	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSTA ST ANTHONY, NEWFOUNDLAND, CANADA	MONITOR/ CONTROL	51 21 37.10N 55 37 28.46W						(1),(4)

LORAN-C CHAIN DATA SHEET

RUSSIAN AMERICAN LORAN-C CHAIN - GRI 5980

STATION	FUNCTION	WGS - 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD	ASSIGNED CSTD (us)	TOLERANCE ECD (us)	TOLERANCE TD	GENERAL NOTES
PETROPAVLOVSK, KAMCHATKA, RUSSIA	MASTER	53 07 47.584N 157 41 42.900E		700	0.0					(1) Dual-rated to Eastern Russian Chain (7950)
ATTU, ATTU ISLAND, ALASKA, USA	XRAY	52 49 44.134N 173 10 49.528E	14467.56 11000	400	0.0					(5) (4) Dual-rated to Northern Pacific Chain (9990)
ALEXANDROVSK, SAKHALEN ISLAND, RUSSIA	YANKEE	51 04 42.80N 142 42 04.95E	31506.50 28000	700	0.0					(1) Dual-rated to Eastern Russian Chain (7950)
KODIAK, KODIAK ISLAND, ALASKA, USA	A-1 MONITOR/ CONTROL					X	TBD 11001.92	± 1.5	± 0.2	

NOTE 1: Primary baseline control of the Russian Transmitting stations as performed/maintained by the Russian master station at Petropavlovsk, Russia.

NOTE 2: The XRAY baseline control process is a mixture of USCG technique (SAM) and Russian Chayka control methods. This process may result in small incremental CSTD changes (50 nanoseconds minimum). These changes will be announced and promulgated through user notices.

LORAN–C CHAIN DATA SHEET

CANADIAN WEST COAST LORAN–C CHAIN – GRI 5990

STATION	FUNCTION	WGS–84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD (us)	CSTD (us)	TOLERANCE ECD (us)	TOLERANCE TD (us)	GENERAL NOTES
WILLIAMS LAKE, BC, CANADA	MASTER/ CONTROL	51 57 58.876N 122 22 01.686W		400	+1.0					(1)(2)(6) Dual–rated to North Central U.S. Chain
SHOAL COVE, AK	XRAY	55 26 20.940N 131 15 19.094W	13343.60 11000	560	0.0					(2)(6) Dual–rated to Gulf of Alaska Loran–C Chain
GEORGE, WA	YANKEE	47 03 48.096N 119 44 38.976W	28927.36 27000	1400	+0.5					(2)(6) Dual–rated to U.S. West Coast Loran–C Chain
PORT HARDY, BC, CANADA	ZULU/ MONITOR	50 36 29.830N 127 21 28.489W	42266.63 41000	350	0.0	M +0.8		± 1.5		(1)
LORMONSITE SANDSPIT, BC, CANADA	MONITOR	55 14 00.0N 131 48 50.0W				X +2.1	11974.42	± 1.5	± 0.1	(3)
LORMONSITE WHIDBEY IS, WA	MONITOR	48 17 38.52N 122 33 59.53W				Y +1.3 Z –0.1	28405.29 42345.64	± 1.5 ± 1.5	± 0.1 ± 0.1	(3)

LORAN–C CHAIN DATA SHEET

NEWFOUNDLAND EAST COAST LORAN–C CHAIN – GRI 7270

STATION	FUNCTION	WGS – 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
COMFORT COVE, NEWFOUNDLAND, CANADA	MASTER	49 19 53.57N 54 51 42.57W		250				(1)
CAPE RACE, NEWFOUNDLAND, CANADA	WHISKEY	46 46 32.286N 53 10 27.606W	12037.49 11000	500	0.0			(1),(5) Dual–rated to Canadian East Coast Chain (5930)
FOX HARBOR, NEWFOUNDLAND, CANADA	XRAY	52 22 35.252N 55 42 27.862W	26148.01 25000	900	0.0			(1),(5) Dual–rated to Canadian East Coast Chain (5930)
LORMONSTA ST. ANTHONY, NEWFOUNDLAND, CANADA	MONITOR/ CONTROL	51 21 37.1N 55 37 27.4W				M W *** X ***	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(1),(4)
LORMONSITE RED HEAD, NEWFOUNDLAND, CANADA	MONITOR	47 43 01.7N 52 42 32.0W						(3)

*** NOTE: THIS CHAIN STILL UNDER DEVELOPMENT AT TIME OF PRINTING

LORAN-C CHAIN DATA SHEET

GULF OF ALASKA LORAN-C CHAIN - GRI 7960

STATION	FUNCTION	WGS - 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD (us)	CSTD (us)	TOLERANCE ECD (us)	TOLERANCE TD (us)	GENERAL NOTES
TOK, AK	MASTER	63 19 42.884N 142 48 31.346W		560	+1.0					(2)
KODIAK, AK	XRAY/ MONITOR/ CONTROL	57 26 20.30N 152 22 10.65W	13804.45 11000	400	0.0	M +0.7 X +2.1	11263.65	± 1.5	± 0.1	(2),(4),(6) Dual-rated to North Pacific Chain (9990)
SHOAL COVE, AK	YANKEE	55 26 20.940N 131 15 19.094W	29651.14 26000	560	0.0					(2),(6) Dual-rated to Canadian West Coast Chain (5990)
PORT CLARENCE, AK	ZULU	65 14 40.372N 166 53 11.996W	47932.52 45000	1000	0.0					(6) Dual-rated to North Pacific Chain (9990)
LORMONSITE JUNEAU, AK	MONITOR	58 21 35.186N 134 35 53.843W				Y +1.4	28559.49	± 1.5	± 0.1	(3)
LORMONSITE FAIRBANKS, AK	MONITOR	64 49 02.860N 147 52 47.300W				Z +0.3	49922.55	± 1.5	± 0.1	(3)
LORMONSITE GALENA, AK ***	MONITOR									(3)

*** LORMONSITE GALENA STILL BEING DEVELOPED AT TIME OF PRINTING

LORAN-C CHAIN DATA SHEET

SOUTHEAST U.S. LORAN-C CHAIN - GRI 7980

STATION	FUNCTION	WGS - 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
MALONE, FL	MASTER/ CONTROL	30 59 38.870N 085 10 08.751W		800	0.0			(6) Dual-rated to Great Lakes Chain (8970)
GRANGEVILLE, LA	WHISKEY	30 43 33.149N 090 49 43.046W	12809.54 11000	800	-0.5			(6) Dual-rated to South Central U.S. Chain (9610)
RAYMONDVILLE, TX	XRAY	26 31 55.141N 097 49 59.539W	27443.38 23000	540	0.0			(6) Dual-rated to South Central U.S. Chain (9610)
JUPITER, FL	YANKEE	27 01 58.63N 080 06 52.97W	45201.88 43000	350	0.0			
CAROLINA BEACH, NC	ZULU	34 03 46.17N 077 54 46.21W	61542.72 59000	800	0.0			(6) Dual-rated to Northeast U.S. Chain (9960)
LORMONSITE MAYPORT, FL	MONITOR	30 22 59.90N 81 25 12.50W				Y +1.7 45290.72 Z +1.6 62073.39	± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE NEW ORLEANS, LA	MONITOR	29 49 17.40N 90 01 43.60W				M +1.8 W +2.0 11612.46 X +1.3 28656.71	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE DESTIN, FL	MONITOR	30 23 03.9 N 86 32 14.9 W						(3)

LORAN–C CHAIN DATA SHEET

NORTH CENTRAL U.S. LORAN–C CHAIN – GRI 8290

STATION	FUNCTION	WGS – 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
HAVRE, MT	MASTER	48 44 38.589N 109 58 53.613W		400	0.0			
BAUDETTE, MN	WHISKEY	48 36 49.947N 094 33 17.915W	14786.56 11000	800	0.0			(6) Dual–rated to Great Lakes Loran–C Chain (8970)
GILLETTE, WY	XRAY	44 00 11.305N 105 37 23.895W	29084.44 27000	540	0.0			(6) Dual–rated to South Central U.S. Chain (9610)
WILLIAMS LAKE, BC, CANADA	YANKEE	51 57 58.876N 122 22 01.686W	45171.62 42000	400	0.0			(6) Dual–rated to Canadian West Coast Chain (5990)
LORMONSITE BISMARCK, ND	MONITOR	46 47 07.164N 100 44 52.023W				M +1.95 W +2.04 14058.72 X +2.02 28303.21	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORSTA MIDDLETOWN, CA	CONTROL	38 46 57.110N 122 29 43.975W						
LORMONSITE SPOKANE, WA	MONITOR	47 36 47N 117 32 57W				Y +1.20 45235.62	± 1.5 ± 0.1	(3)
LORMONSITE MEDICAL LAKE, WA	MONITOR	47 33 03N 117 43 35W						(3)

LORAN-C CHAIN DATA SHEET

GREAT LAKES LORAN-C CHAIN - GRI 8970

STATION	FUNCTION	WGS - 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
DANA, IN	MASTER	39 51 07.658N 087 29 11.586W		400	-0.5			(6) Dual-rated to Northeast U.S. Chain (9960)
MALONE, FL	WHISKEY	30 59 38.870N 085 10 08.751W	14355.11 11000	800	0.0			(6) Dual-rated to Southeast U.S. Chain (7980)
SENECA, NY	XRAY/ CONTROL	42 42 50.716N 076 49 33.308W	31162.06 28000	800	0.0			(6) Dual-rated to Northeast U.S. Chain (9960)
BAUDETTE, MN	YANKEE	48 36 49.947N 094 33 17.915W	47753.74 44000	800	0.0			(6) Dual-rated to North Central U.S. Chain (8290)
BOISE CITY, OK	ZULU	36 30 20.783N 102 53 59.487W	63669.46 59000	900	0.0			(6) Dual-rated to South Central U.S. Chain (9610)
EECEN, WILDWOOD, NJ	TANGO	38 56 58.22N 74 52 01.57W	71617.92 72000	Various				Experimental station. NOT to be used for navigational use.
LORMONSITE DUNBAR FOREST, MI	MONITOR	46 19 24.7 N 84 13 17.9 W				M +2.2 X +2.0 30978.80 Y +0.7 47929.82	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE PLUMBROOK, OH	MONITOR	44 22 47.1 N 82 39 37.9 W						(3)
LORMONSITE LITTLE ROCK, AK	MONITOR	34 43 55.083N 092 14 08.489W				W +2.8 14601.09 Z +2.1 64599.62	± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE NEW ORLEANS, LA	MONITOR	29 49 17.40N 90 01 43.60W						(3)

LORAN-C CHAIN DATA SHEET

SOUTH CENTRAL U.S. LORAN-C CHAIN – GRI 9610

STATION	FUNCTION	WGS – 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
BOISE CITY, OK	MASTER	36 30 20.783N 102 53 59.487W		900	0.0			(6) Dual-rated to Great Lakes Chain (8970)
GILLETTE, WY	VICTOR	44 00 11.305N 105 37 23.895W	13884.48 11000	540	0.0			(6) Dual-rated to North Central U.S. Chain (8290)
SEARCHLIGHT, NV	WHISKEY	35 19 18.305N 114 48 16.881W	28611.81 25000	540	0.0			(6) Dual-rated to U.S. West Coast Chain (9940)
LAS CRUCES, NM	XRAY	32 04 18.130N 106 52 04.388W	42044.93 40000	540	0.0			
RAYMONDVILLE, TX	YANKEE	26 31 55.141N 097 49 59.539W	56024.80 52000	540	0.0			(6) Dual-rated to Southeast U.S. Chain (7980)
GRANGEVILLE, LA	ZULU	30 43 33.149N 090 49 43.046W	69304.00 65000	800				(6) Dual-rated to Southeast U.S. Chain (7980)
LORMONSITE LITTLE ROCK, AK	MONITOR	34 43 55.083N 092 14 08.489W				Z +2.60 67561.09	± 1.5 ± 0.1	(3)
LORMONSITE GRAND JUNCT, CO	MONITOR	39 07 24.790N 108 30 58.180W				M +1.5 V +1.80 13949.76 W +2.50 29033.22	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE MIDLAND, TX	MONITOR	31 56 53.609N 102 12 32.499W				X +2.20 41814.55 Y +1.60 56780.08	± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE BISMARK, ND	MONITOR	46 47 07.164N 100 44 52.023W						(3)

LORAN-C CHAIN DATA SHEET

U.S. WEST COAST LORAN-C CHAIN - GRI 9940

STATION	FUNCTION	WGS-84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
FALLON, NV	MASTER	39 33 06.740N 118 49 55.816W		400	+1.0			
GEORGE, WA	WHISKEY	47 03 48.096N 119 44 38.976W	13796.90 11000	1400	+0.5			(2),(6) Dual-rated to Canadian West Coast Chain (5990)
MIDDLETOWN, CA	XRAY/ CONTROL	38 46 57.110N 122 29 43.976W	28094.50 27000	400	+0.5			(2)
SEARCHLIGHT, NV	YANKEE	35 19 18.305N 114 48 16.881W	41967.30 40000	560	0.0			(2)(6) Dual-rated to South Central U.S. Chain (9610)
LORMONSITE POINT PINOS, CA	MONITOR	36 38 12.36N 121 56 07.95W				M +1.4 X +1.6 27494.29 Y +1.7 42756.06	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE POINT CABRILLO, CA	MONITOR	39 20 54.1 N 123 40 29.4 W				W +0.2 15428.14	± 1.5 ± 0.1	(3)

LORAN-C CHAIN DATA SHEET

NORTHEAST U.S. LORAN-C CHAIN - GRI 9960

STATION	FUNCTION	WGS - 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
SENECA, NY	MASTER/ CONTROL	42 42 50.716N 076 49 33.308W		800	0.0			(6) Dual-rated to Great Lakes Chain (8970)
CARIBOU, ME	WHISKEY	46 48 27.305N 067 55 37.159W	13797.20 11000	800	0.0			(6) Dual-rated to Canadian East Coast Chain (5930)
NANTUCKET, MA	XRAY	41 15 12.046N 069 58 38.536W	26969.93 25000	400	0.0			(6) Dual-rated to Canadian East Coast Chain (5930)
CAROLINA BEACH, NC	YANKEE	34 03 46.17N 077 54 46.21W	42221.65 39000	800	0.0			(6) Dual-rated to Northeast U.S. Chain (9960)
DANA, IN	ZULU	39 51 07.658N 087 29 11.586W	57162.06 54000	400	-0.5			(6) Dual-rated to Great Lakes Chain (8970)
EECEN, WILDWOOD, NJ	TANGO	38 56 58.22N 074 52 01.57W	81500.49 80000	Various				Experimental station. NOT to be used for navigational use.
LORMONSITE CAPE ELIZABETH, ME	MONITOR	43 33 54.90N 070 11 57.90W				W +1.2 13311.48	± 1.5 ± 0.1	(3)
LORMONSITE SANDY HOOK, NJ	MONITOR	40 28 17.10N 074 01 03.10W				M +2.0 X +1.5 26999.78 Y +2.1 43720.37	± 1.5 ± 1.5 ± 0.1 ± 1.5 ± 0.1	(3)
LORMONSITE PLUMBROOK, OH	MONITOR	41 22 47.1 N 082 39 37.9 W				Z +1.5 56950.89	± 1.5 ± 0.1	(3)
LORMONSITE DUNBAR FOREST, MI	MONITOR	46 19 24.7N 084 13 17.9W						(3)

LORAN–C CHAIN DATA SHEET

NORTH PACIFIC LORAN–C CHAIN – GRI 9990

STATION	FUNCTION	WGS – 84 COORDINATES	EMISSION/ CODING DELAY, us	RADIATED PEAK POWER,KW	NOMINAL ECD,us	CSECD CSTD (us)	TOLERANCE ECD (us) TD	GENERAL NOTES
ST PAUL, PRIBILOF IS, AK	MASTER	57 09 12.350N 170 15 06.245W		400	0.0			(4)
ATTU, ATTU IS, AK	XRAY	52 49 44.134N 173 10 49.528E	14875.25 11000	400	0.0			(4),(5) Dual–rated to Russian American Chain 5980
PORT CLARENCE, AK	YANKEE	65 14 40.372N 166 53 11.996W	32068.95 29000	1000	0.0			(6) Dual–rated to Gulf of Alaska Chain (7960)
KODIAK, NARROW CAPE, AK	ZULU/ CONTROL	57 26 20.30N 152 22 10.65W	46590.45 43000	400	0.0			(6) Dual–rated to Gulf of Alaska Chain (7960)
LORMONSITE KODIAK, AK	MONITOR	57 49 24.095N 152 19 41.386W				M +0.1 Z +2.1 43146.93	± 1.5 ± 1.5 ± 0.1	
LORMONSITE ST PAUL, AK	MONITOR	57 09 15.852N 170 13 13.948W						
LORMONSITE ADAK IS., AK	MONITOR	51 57 10.611 N 176 36 26.069 W				X +1.2 14848.23 Y +0.6 34977.00	± 1.5 ± 0.1 ± 1.5 ± 0.1	

APPENDIX B: PREDICTED LORAN-C GROUNDWAVE COVERAGE

TABLE OF CONTENTS

PREDICTED LORAN-C GROUNDWAVE COVERAGE

1. INTRODUCTION.
   The attached diagrams show the predicted Loran-C groundwave coverage for each chain. A brief discussion of how the coverage diagrams are generated follows:

   A. Geometric-fix-accuracy limits.
      Each of two LOP's in each Loran-C chain is assigned a TD standard deviation of 0.1 microseconds. The geometric-fix-accuracy is assigned a value of 1500 feet, 2dRMS. Using the two constraints above a contour is generated within the area of the Loran-C chain. This contour represents the geometric-fixaccuracy limits.

   B. Range limits.

      (1) Predicted atmospheric noise field strength is calculated for a judiciously selected point in the middle of the service area for each chain. The predicted noise is the average of noise levels calculated to be exceeded only 5% of the time over each 4-hour period of a day for each season of the year.

      (2) Cross-rate Loran-C signals act as interference and can limit reception in some areas. Where signals from adjacent Loran-C chains are relatively strong, values for noise are generally increased to compensate for the additional interference.

      (3) Predicted atmospheric noise for each Loran-C chain is combined with estimated Loran-C signal strength for each Loran-C transmitting station to obtain expected 1:3 SNR range limits for each transmitted signal.

      (4) Where valid measurements of signal strength have been made in a Loran-C service area, these have been incorporated into the coverage diagrams in the form of revised limits.

   C. To generate the predicted Loran-C coverage diagrams, the geometric-fix-accuracy limits and predicted SNR range limits are combined on a geographic plot for each Loran-C, chain. The area within both the geometric and range limits is the coverage area shown.

2. SAMPLE NOISE CALCULATION.
   The predicted noise is determined from data contained in CCIR Report 322-3, Characteristics and Applications of

Atmospheric Radio Noise, Geneva 1988. A sample noise calculation follows:

A. Definition of terms:

Fa = Effective antenna noise factor which results from the external noise power available from a loss free antenna.

Fam = Median of the hourly values of Fa within a fourhour time block.

Du = Value of the average noise power exceeded for 10% of the hours within a four-hour time block (dB above the time block median).

En = root-mean-square (RMS) noise field strength for a lkHz bandwidth (dB/luV/m).

D = RMS noise value added to the time block median to change the percentage of time exceeded from 50% to the desired value; desired value is 5% for the calculations below.

CF = correction factor used to permit calculation for any given bandwidth. CF = (10 log 10 BW) - 30 in units of dB above 1uV/m.

B. For the purpose of this sample noise calculation, assume position with latitude 40 0 N and longitude 135 degrees W.

C. Determine Fam (lHz) from Figures 2A-25A (CCIR 322). For this example Fam (1 MHz) is tabulated in Table 1. The first data sample for winter, 0000 - 0400, Figure 2A (CCIR 322), will be used to illustrate how the other rows of Table 1 are calculated.

Fam (lMHz) = 60.0

D. Determine Fam for 100 kHz from Figure 2B (CCIR 322) which uses frequency and curves parametric in Fam (I MHz) as the entering arguments.

Fam (100 kHz) = 108.0

E. Determine Du for 100 kHz from Figure 2C (CCIR 322).

Du (100 kHz) = 9.0

F. Calculate En using Equation (2), p. 6, CCIR 322.

En = Fam (lOOkHz)   65.5 + 20 log 10 f(MHz)

For Fam (100 kHz)   108.0 and f = 100 kHz,

$$En = 108.0 - 65.5 + 20 \log 10 (0.1)$$

$$En = 22.5$$

G. D, the incremental noise value, is calculated from Du as follows:

$$D = 1.3 (Du) = 1.3 (9.0) = 11.7$$

The constant factor, 1.3, has been determined by graphical construction using the technique described on p. 10, CCIR 322.

H. CF is calculated to correct the noise level to the desired noise bandwidth, i.e., 30 kHz:

$$CF = 10 \log 10\ BW - 30 = 14.77$$

I. The noise level which will not be exceeded more than 5% of the time for a four-hour time block is:

$$N = En + D + CF$$

$$N = 22.5 + 11.7 + 14.77$$

$$N = 48.97 \text{ dB above 1 uV/m}$$

J. Steps (b) thru (i) above are repeated for each fourhour time block given in CCIR 322. These calculations are tabulated in Table 1 below.

K. The average value of the noise levels calculated for each time block (right-most column, Table 1) becomes the noise level which is used in combination with the Loran-C signal strengths to estimate range limits throughout the Loran-C service area.

Time Block	Fam. (I Mhz)	Fam (100 kHz)	Du (100 kHz)	En	D(5%)	CF	N
00-04/Wl	60	108	9.0	22.5	11.7	14.77	48.97
04-08/WI	56	104	13.0	18.5	16.9	14.77	50.17
08-12/WI	25	85	13.8	-0.5	17.9	14.77	32.21
12-16/WI	27	83	13.8	-2.5	17.9	14.77	30.21
16-20/WI	41	95	13.8	9.5	17.9	14.77	42.21
20-24/WI	59	106	9.8	20.5	12.7	14.77	48.01
00-04/SP	65	112	9.0	26.5	11.7	14.77	52.97
04-08/SP	45	99	13.5	13.5	17.6	14.77	45.82
08-12/SP	25	89	15.5	3.5	20.2	14.77	38.42
12-16/SP	32	93	17.0	7.5	22.1	14.77	44.37
16-20/SP	46	97	16.0	11.5	20.8	14.77	47.07
20-24/SP	66	112	10.0	26.5	13.0	14.77	54.27
00-04/SU	58	110	8.0	24.5	10.4	14.77	49.67
04-08/SU	45	103	12.5	17.5	16.3	14.77	48.52
08-12/SU	19	88	13.2	2.5	17.2	14.77	34.43
12-16/SU	36	93	12.5	7.5	16.3	14.77	38.52
16-20/SU	54	106	11.3	20.5	14.7	14.77	49.96
20-24/SU	66	114	7.9	28.5	10.3	14.77	53.54
00-04/AU	70	113	9.0	26.5	11.7	14.77	52.97
04-08/AU	52	105	13.9	19.5	18.7	14.77	52.34
08-12/AU	27	94	16.7	8.5	21.7	14.77	44.98
12-16/AU	30	93	16.5	7.5	21.5	14.77	43.77
16-20/AU	57	106	14.5	20.5	18.9	14.77	54.12
20-24/AU	68	114	9.8	28.5	12.7	14.77	56.01

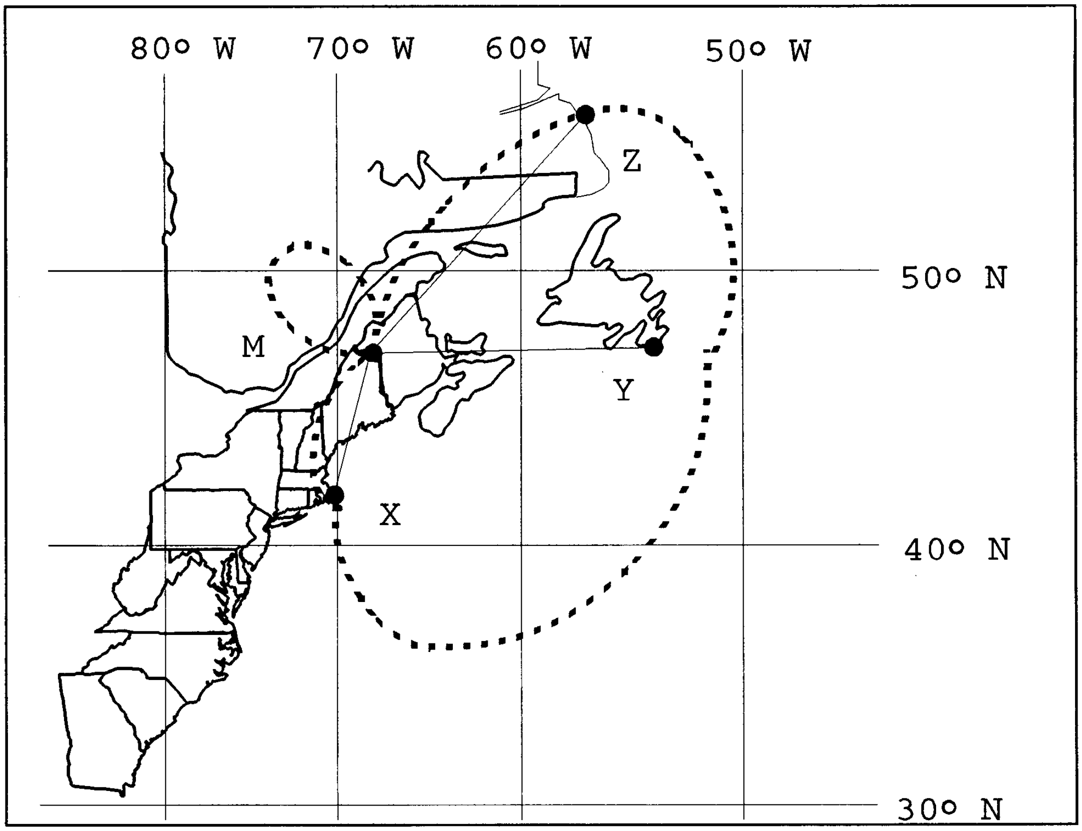
TOTAL = 1113.50

AVG = 46.4 dB above luV/m

TABLE 1 - SAMPLE NOISE CALCULATION FOR
LATITUDE 40 degrees N, LONGITUDE 135 degrees W.

COMDTINST M16562.4A

Canadian East Coast Loran-C Chain
GRI 5930

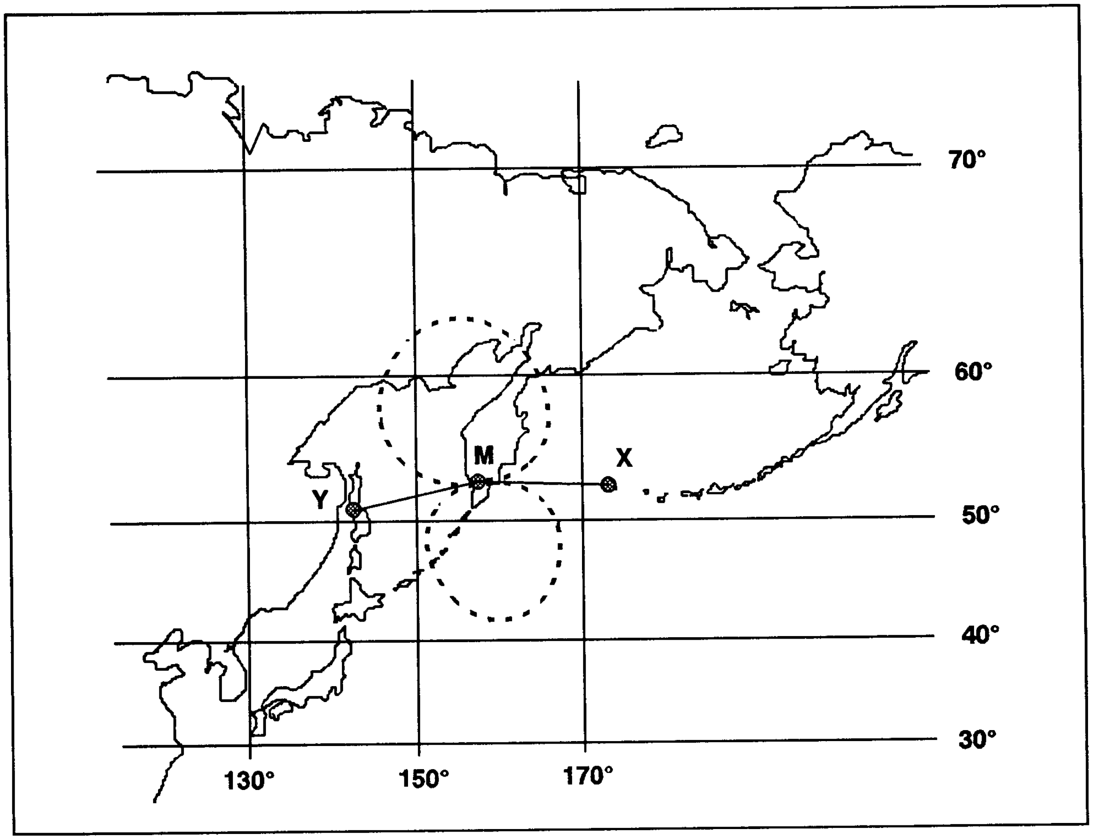


SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	47.6 dB above 1μV/m

Transmitter	Coordinates		CD (μS)	Power (kW)
M Caribou, ME	46°48'27.305"N	67°55'37.159"W		800
X Nantucket, MA	41°15'12.046"N	69°58'38.536"W	11000	400
Y Cape Race, CAN	46°46'32.286"N	53°10'27.606"W	25000	500
Z Fox Harbor, CAN	52°22'35.252"N	55°42'27.862"W	38000	900

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

Russian American Loran-C Chain
GRI 5980

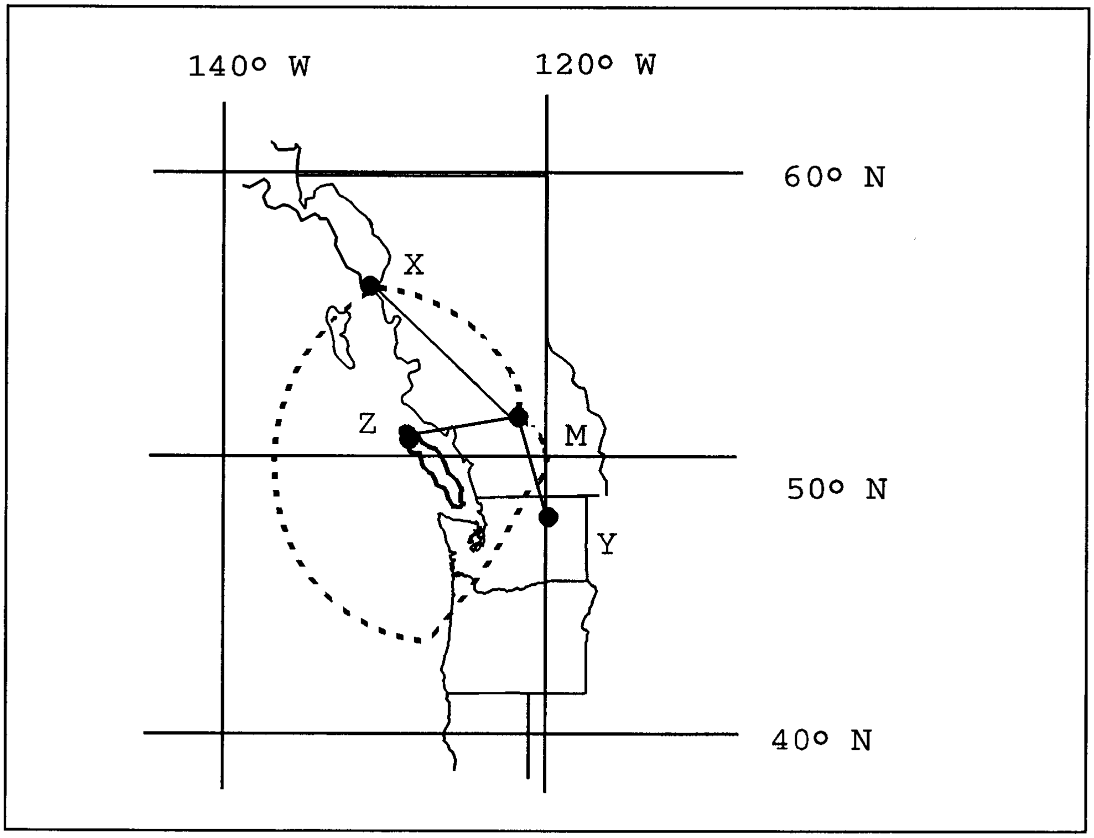


SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	44.4 dB above 1μV/m

Transmitter	Coordinates		CD (μS)	Power (kW)
M Petropavlovsk, CIS	53°07'47.584"N	157°41'42.900"E		700
X Attu, AK, USA	52°49'44.134"N	173°10'49.528 E	11000	400
Y Alexandrovsk, CIS	51°04'42.80" N	142°42'04.95" E	28000	700

NOTE: <u>Estimated</u> Groundwave Coverage, actual coverage will vary.

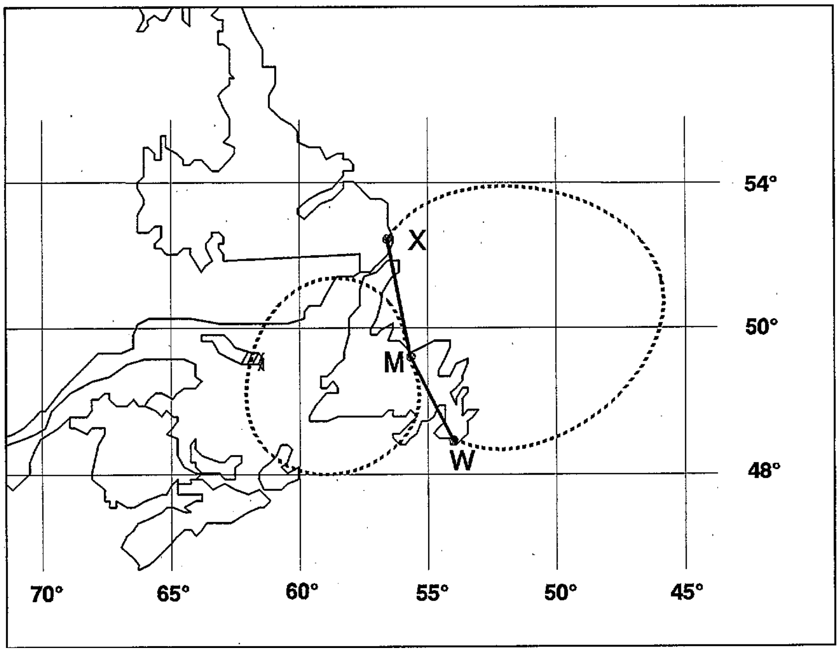
Canadian West Coast Loran-C Chain
GRI 5990



SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	46.4 dB above 1μV/m

Transmitter	Coordinates		CD (μS)	Power (kW)
M Williams Lake, CAN	51°57'58.876"N	122°22'01.686"W		400
X Shoal Cove, AK, USA	55°26'20.940"N	131°15'19.094"W	11000	560
Y George, WA, USA	47°03'48.096"N	119°44'38.976"W	27000	1400
Z Port Hardy, CAN	50°36'29.830"N	127°21'28.489"W	41000	350

NOTE: <u>Estimated</u> Groundwave Coverage, actual coverage will vary.

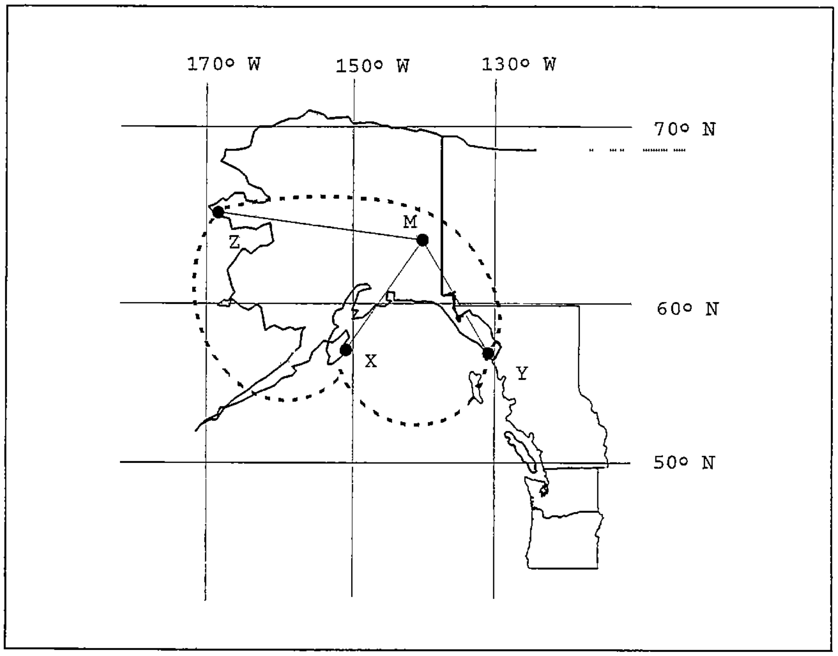


Newfoundland East Coast Loran-C Chain

SNR			1:3	
Fix Accuracy			1/4 NM (95% 2 dRMS)	
Atmospheric Noise			44.4 dB above 1 V/m	
Transmitter	Coordinates		CD (S)	Power (kW)
M Comfort Cove, CAN	4919'53.57" N	354 51'42.57" W		250
W Cape Race, CAN	46 46'32.286"N	05310'27.606"W	11000	500
X Fox Harbor, CAN	52 22'35.252"N	05542'27.862"W	25000	900

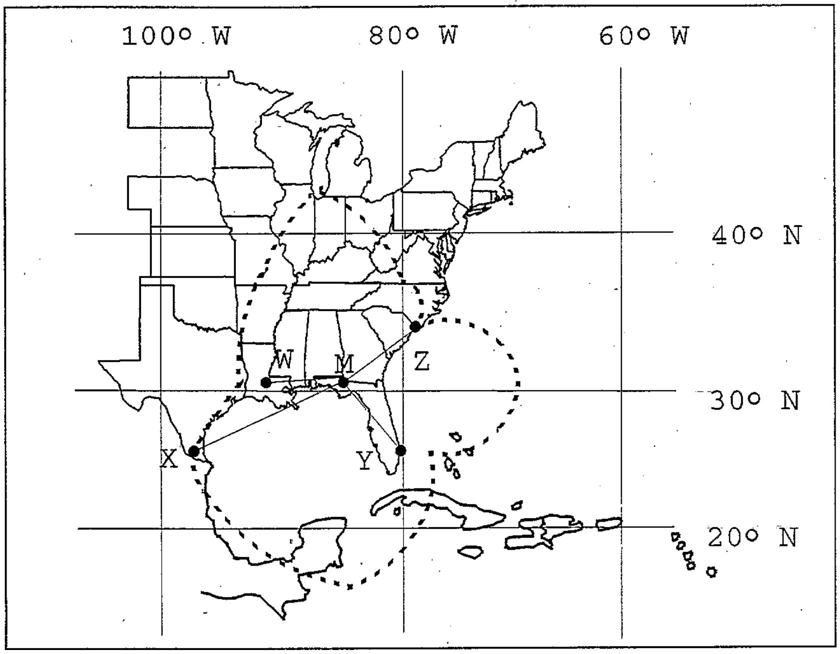
NOTE: Estimated Groundwave Coverage, actual coverage will vary.

Gulf of Alaska Loran-C Chain
GR1 7960



SNR			1:3	
Fix Accuracy			1/4 NM (95% 2 dRMS)	
Atmospheric Noise			49.0 dB above 1 V/m	
Transmitter	Coordinates		CD (S)	Power (kW)
M Tok, AK	63 19'42.884"N	14248'31.346"W		560
X Kodiak, AK	5726'20.30"N	152 22'10.65"W	11000	400
Y Shoal Cove, AK	5526'20.940"N	131 15'19.094"W	26000	560
Z Port Clarence, AK	6514'40.372"N	166 53'11.996"W	45000	1000

NOTE: Estimated Groundwave Coverage, actual coverage will vary.



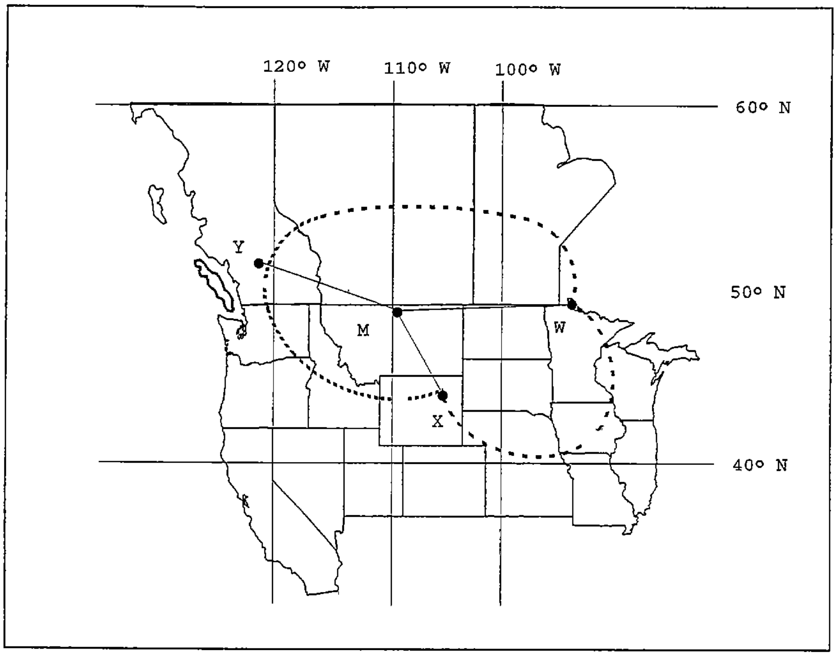
Southeast U.S. Loran-C Chain

SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	60.5 dB above 1 V/m

Transmitter	Coordinates		CD (S)	Power (kW)
M Malone, FL	3059'38.870"N	085 10'08.751"W		800
W Grangeville, LA	3043'33.149"N	090 49'43.046"W	11000	800
X Raymondville, TX	2631'55.141"N	097 49'59.539"W	23000	540
Y Jupiter, FL	2701'58.63"N	080 06'52.97"W	43000	350
Z Carolina Beach, FL	3403'46.17"N	077 54'46.21"W	59000	600

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

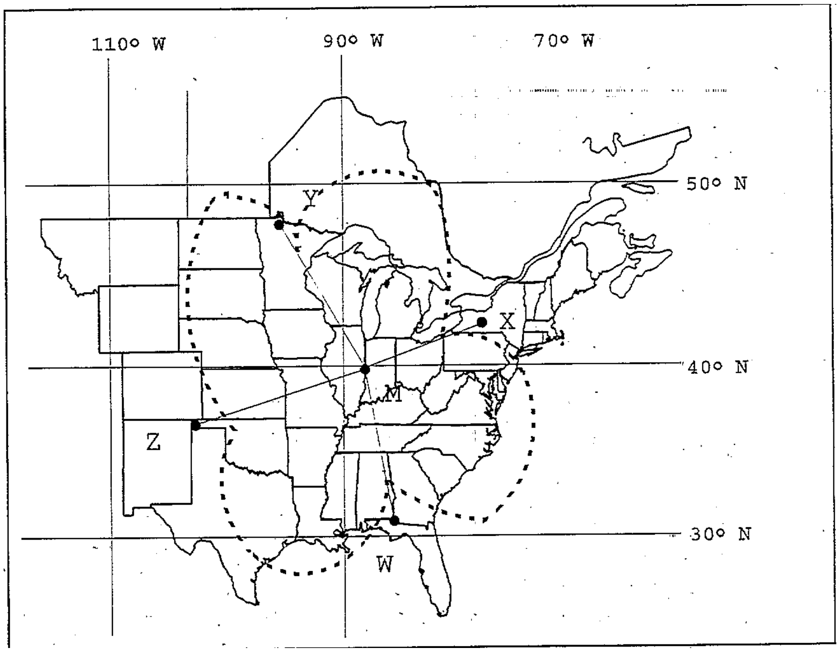
North Central U.S. Loran-C Chain
GR1 8290



SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	57.8 dB above 1 V/m

Transmitter	Coordinates		CD (S)	Power (kW)
M Havre, MT	4844'38.589"N	109 58'53.613"W		400
X Baudette, MN	4836'49.947"N	094 33'17.915"W	11000	800
Y Gillette, WY	4400'11.305"N	105 37'23.895"W	27000	540
Z Williams Lake, CAN	5157'58.876"N	122 22'01.686"W	42000	400

NOTE: <u>Estimated</u> Groundwave Coverage, actual coverage will vary.

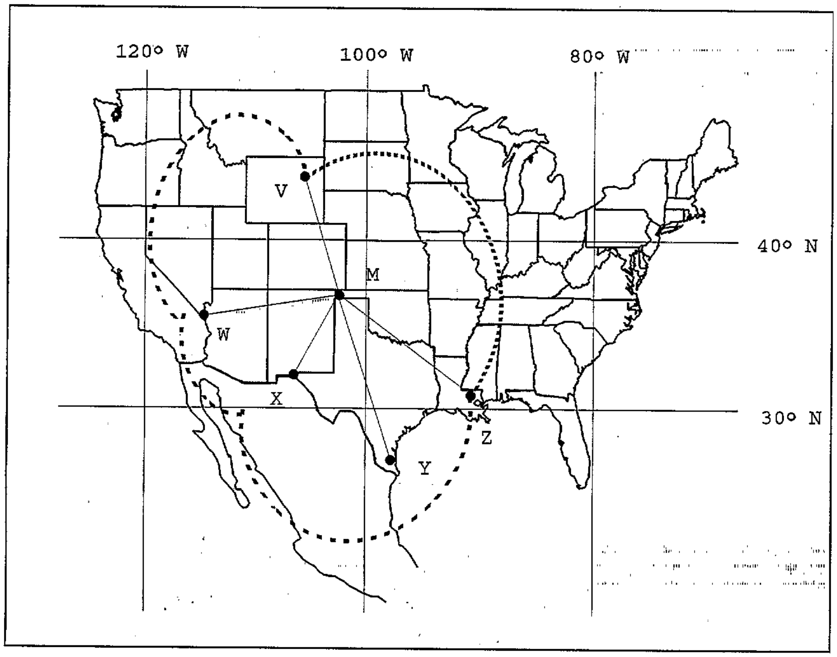


Great Lakes Loran-C Chain

SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	58.1 dB above 1 V/m

Transmitter	Coordinates		CD (S)	Power (kW)
M Dana, IN	3951'07.658"N	087 29'11.586"W		400
W Malone, FL	3059'38.870"N	085 10'08.751"W	11000	800
X Seneca, NY	4242'50.716"N	076 49'33.308"W	28000	800
Y Baudette, MN	4836'49.947"N	094 33'17.915"W	44000	800
Z Boise City, OK	3630'20.783"N	102 53'59.487"W	59000	900

NOTE: <u>Estimated</u> Groundwave Coverage, actual coverage will vary.



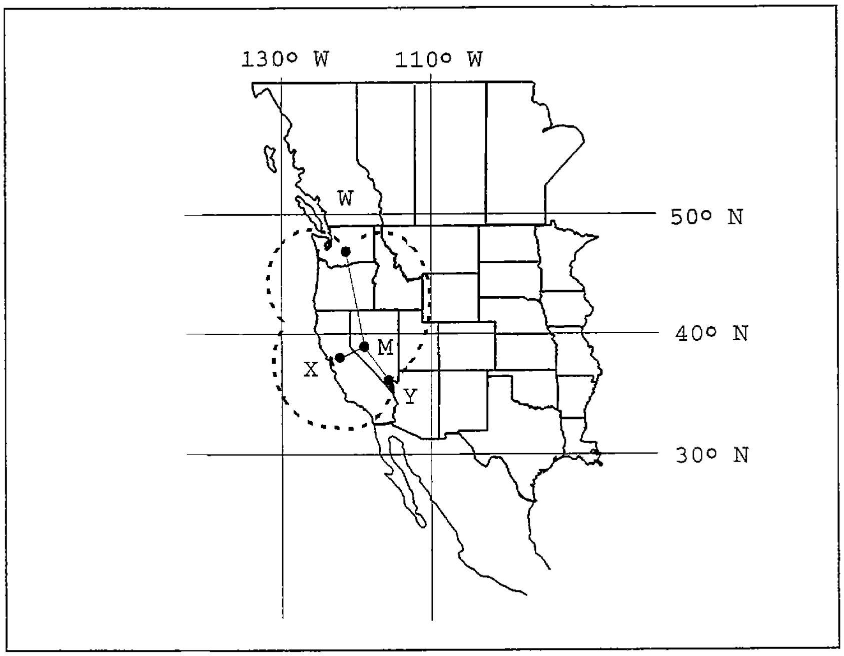
South Central U.S. Loran-C Chain

SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	57.8 dB above 1 V/m

Transmitter	Coordinates		CD (S)	Power (kW)
M Boise City, OK	3630'20.783"N	102 53'59.487"W		900
V Gillette, WY	4400'11.305"N	105 37'23.895"W	11000	540
W Searchlight, NV	3519'18.305"N	114 48'16.881"W	25000	540
X Las Cruces, NM	3204'18.130"N	106 52'04.388"W	40000	540
Y Raymondville, TX	2631'55.141"N	097 49'59.539"W	52000	540
Z Grangeville, LA	3043'33.149"N	090 49'43.046"W	65000	800

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

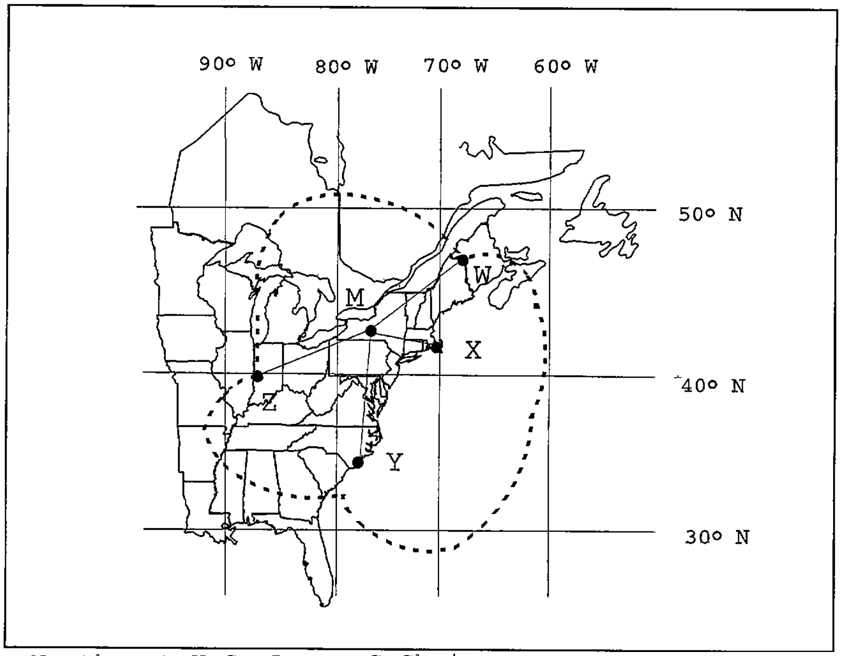
U.S. West Coast Loran-C Chain
GR1 9940



SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	52.4 dB above 1 V/m

Transmitter	Coodinates		CD (S)	Power (kW)
M Fallon, NV	3933'06.740"N	118 49'55.816"W		400
W George, WA	4703'48.096"N	119 44'38.976"W	11000	1400
X Middletown, CA	3846'57.110"N	122 29'53.975"W	27000	400
Y Searchlight, NV	3519'18.305"N	114 48'16.881"W	40000	560

NOTE: <u>Estimated</u> Groundwave Coverage, actual coverage will vary.

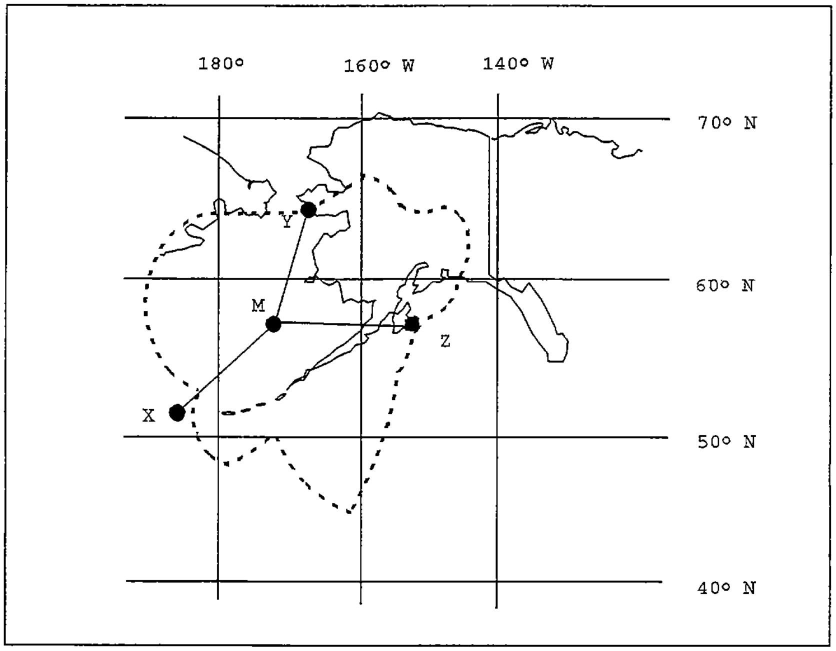


Northeast U.S. Loran-C Chain

SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	55.1 dB above 1 V/m

Transmitter	Coordinates		CD (S)	Power (kW)
M Seneca, NY	4242'50.716"N	076 49'33.308"W		800
W Caribou, ME	4648'27.305"N	067 55'37.159"W	11000	800
X Nantucket, MA	4115'12.046"N	06958'38.536"W	25000	400
Y Carolina Beach, NC	34 03'46.17"N	07754'46.21"W	39000	600
Z Dana, IN	39 51'07.658"N	08729'11.586"W	54000	400

NOTE: Estimated Groundwave Coverage, actual coverage will vary.



North Pacific Loran-C Chain GR1 9990

SNR	1:3
Fix Accuracy	1/4 NM (95% 2 dRMS)
Atmospheric Noise	48.2 dB above 1(?)V/m

Transmitter	Coordinates		CD (S)	Power (kW)
M St. Paul, AK	57 09'12.350"N	17015'06.245"W		400
X Attu, AK	52 49'44.134"N	17310'49.528"E	11000	400
Y Port Clarence, AK	65 14'40.372"N	16653'11.996"W	29000	1000
Z Kodiak, AK	57 26'20.30"N	15222'10.65"W	43000	400

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

This page intentionally left blank.

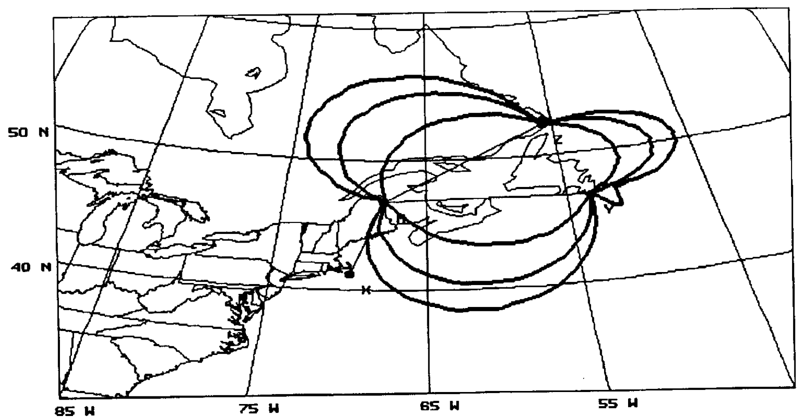
APPENDIX C: LORAN-C CHAIN GEOMETRY CONTOURSM

TABLE OF CONTENTS

LORAN-C CHAIN GEOMETRY CONTOURS

NOTE: The following pages contain 2DRMS (95%) geometry contours for each triad of each Loran-C chain. Calculations are based on a 0.1 us standard deviation. These are not coverage diagrams as range limits have not been included. This information is intended to assist users in selecting the most accurate triad in a given area.

LORAN-C GRI 5930
CANADIAN EAST COAST CHAIN (CEC)

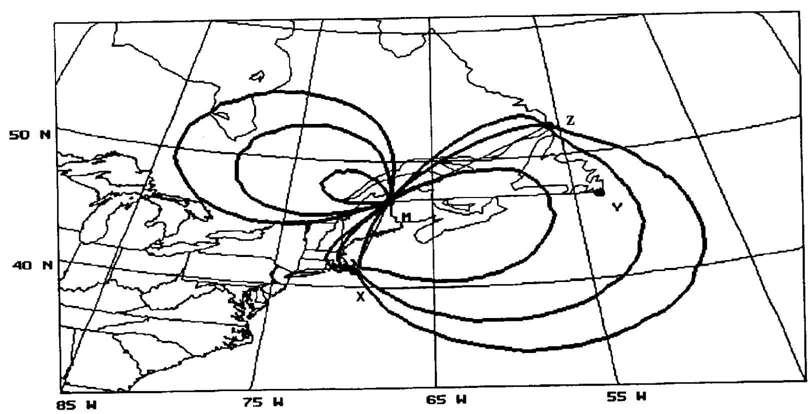


MYZ

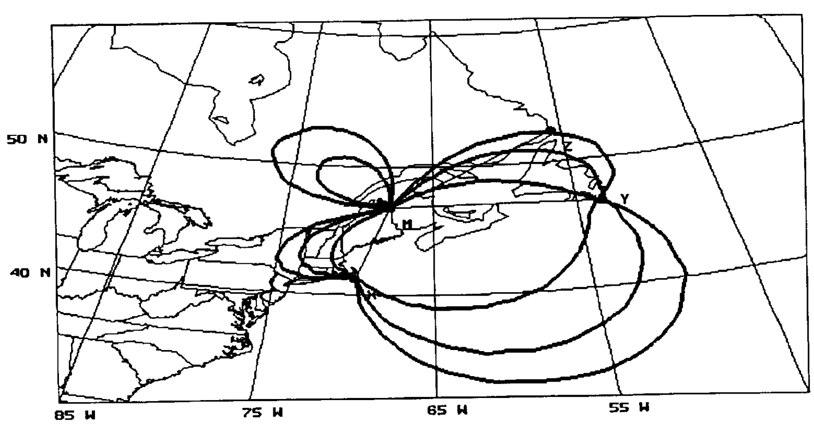
2 drms Fix Accuracy
with σ = 0.1 *us*

Inner curve - 500 ft.
Middle curve - 1000 ft.
Outer curve - 1500 ft.

Note: These contours are based on geometry only, and do not include range limits.



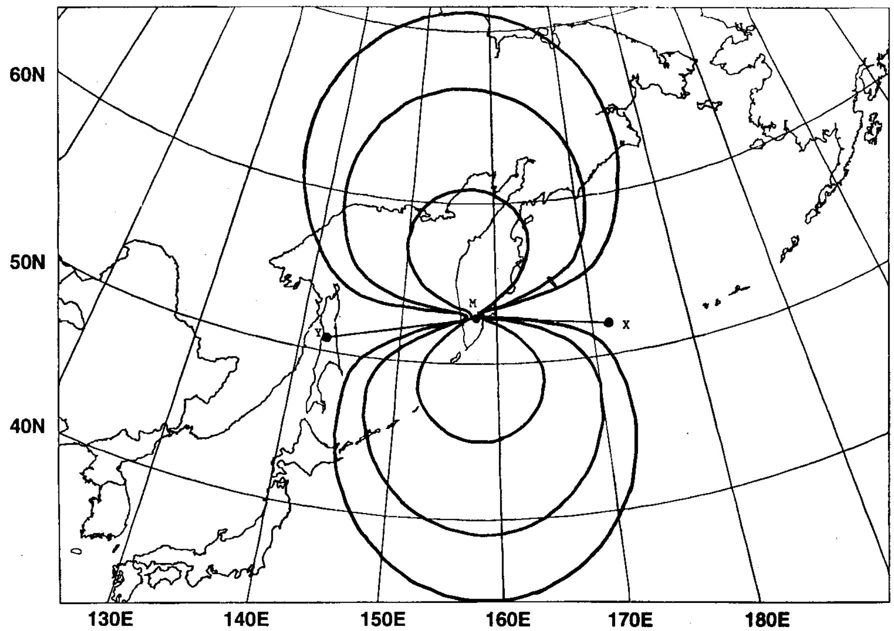
MXZ



MXY

Loran-C GRI 5930 Canadian East Coast Chain (CEC)

LORAN-C GRI 5980
RUSSIAN AMERICAN CHAIN (RAC)



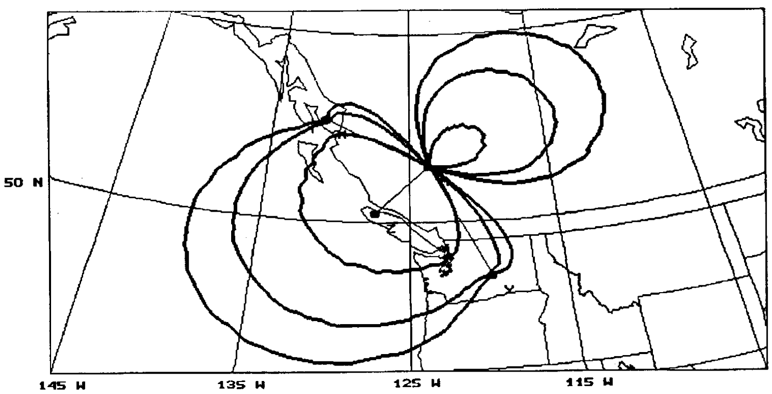
MXY

2 drms Fix Accuracy with $\sigma = 0.1$ *us*

Inner curve - 500 ft.
Middle curve - 1000 ft.
Outer curve - 1500 ft.

Note: These contours are based on geometry only, and do not include range limits.

LORAN-C GRI 5990
CANADIAN WEST COAST CHAIN (CWC)

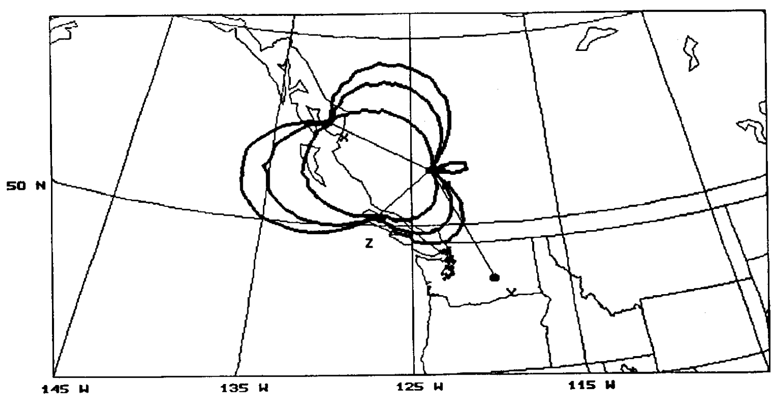


MXY

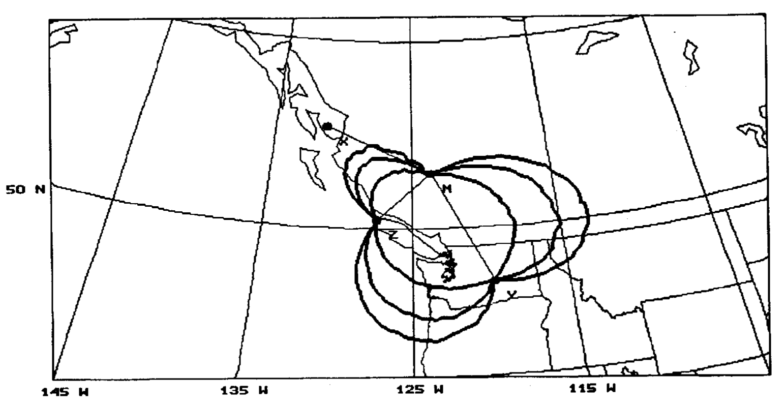
2 drms Fix Accuracy
with σ = 0.1 *us*

Inner curve -500 ft.
Middle curve-1000 ft.
Outer curve -1500 ft.

Note: These contours are based on geometry only, and do not include range limits.

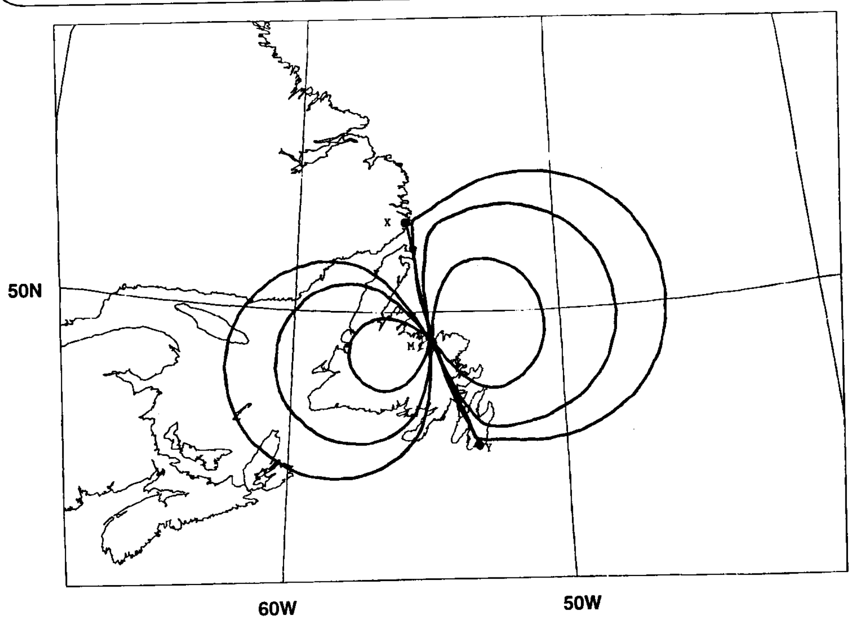


MXZ



MYZ

LORAN-C GRI 7270
NEWFOUNDLAND EAST COAST CHAIN (NEC)



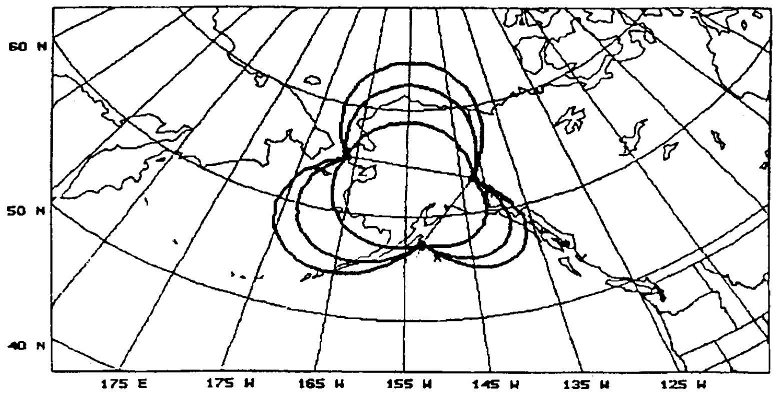
MXY

2 drms Fix Accuracy
with σ = 0.1 *us*

Inner curve - 500 ft.
Middle curve - 1000 ft.
Outer curve - 1500 ft.

Note: These contours are based on geometry only, and do not include range limits.

LORAN-C GRI 7960
GULF OF ALASKA CHAIN (GOA)

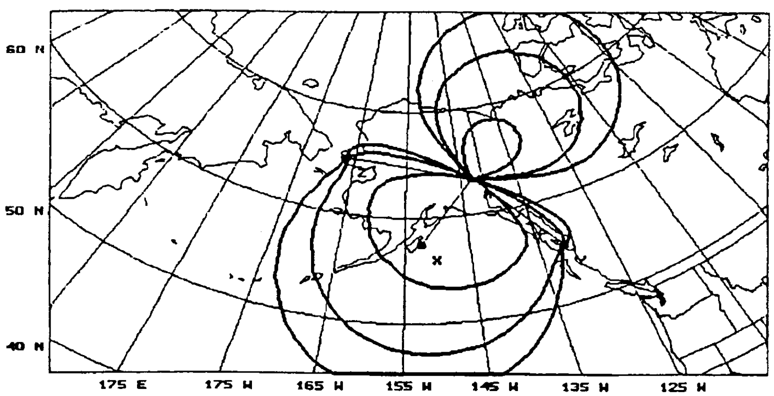


MXZ

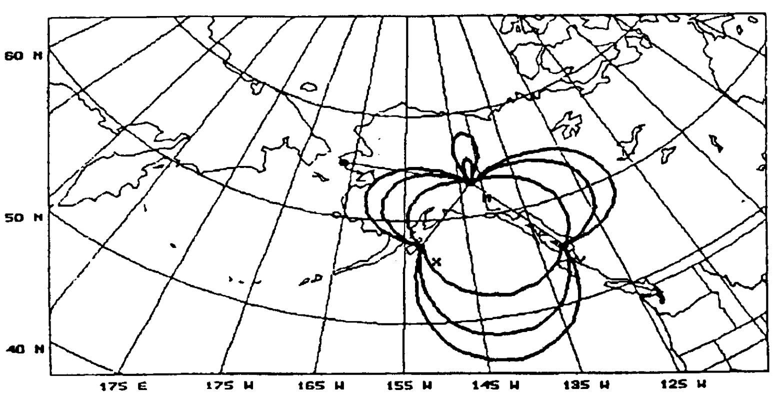
2 drms Fix Accuracy
with σ = 0.1 *us*

Inner curve -500 ft.
Middle curve-1000 ft.
Outer curve -1500 ft.

Note: These contours are based on geometry only, and do not include range limits.

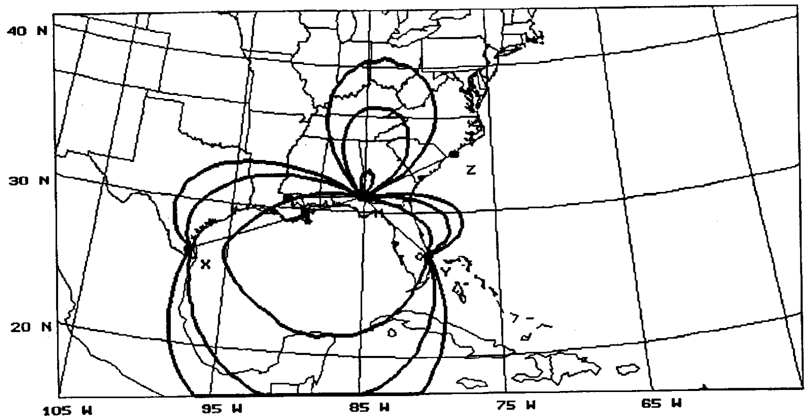


MYZ



MXY

LORAN-C GRI 7980
SOUTHEAST U.S. CHAIN (SEUS)

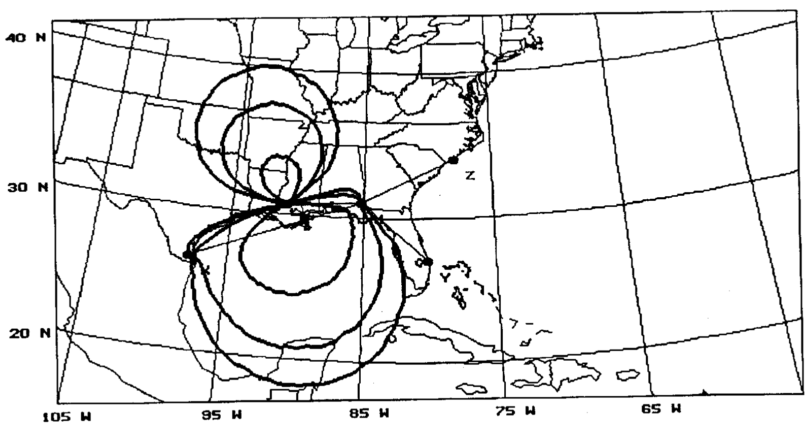


MXY

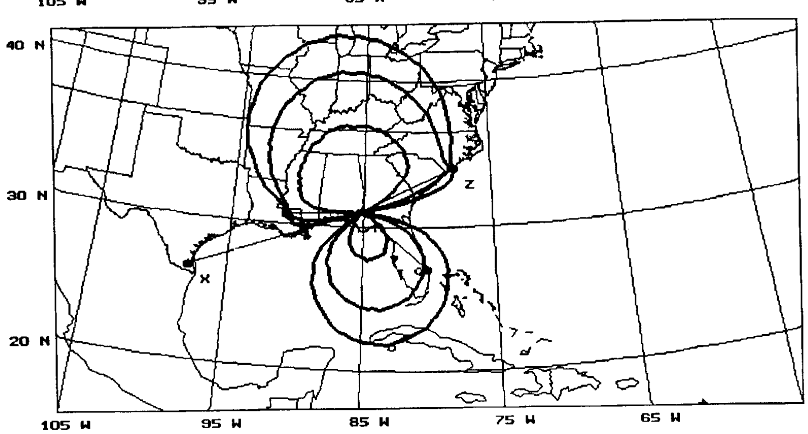
2 drms Fix Accuracy
with σ = 0.1 *us*

Inner curve -500 ft.
Middle curve-1000 ft.
Outer curve -1500 ft.

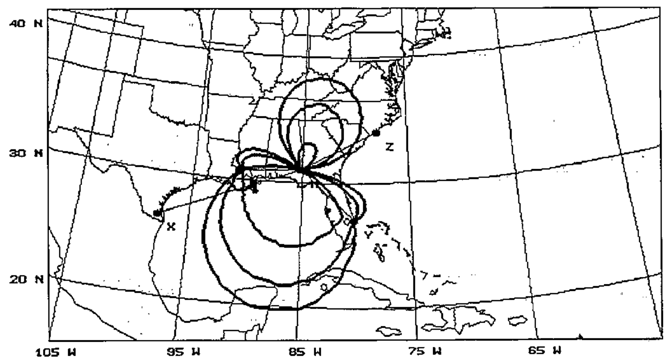
Note: These contours are based on geometry only, and do not include range limits.



MWX

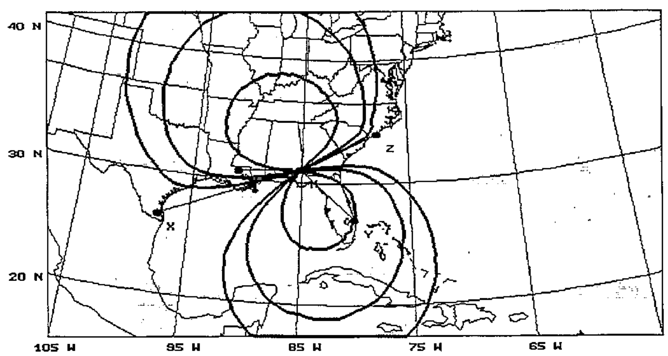


MWZ



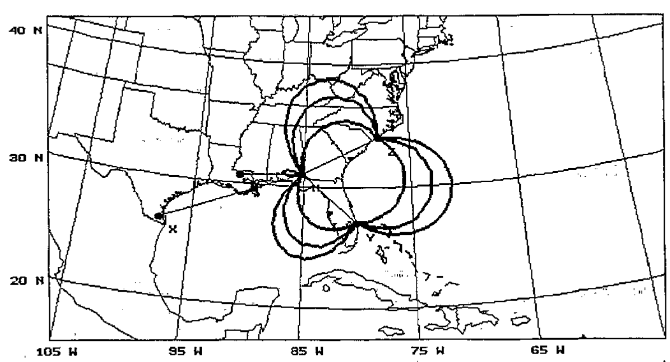
40 N
30 N
20 N
105 W
95 W
85 W
75 W
65 W
X
Z

MWY



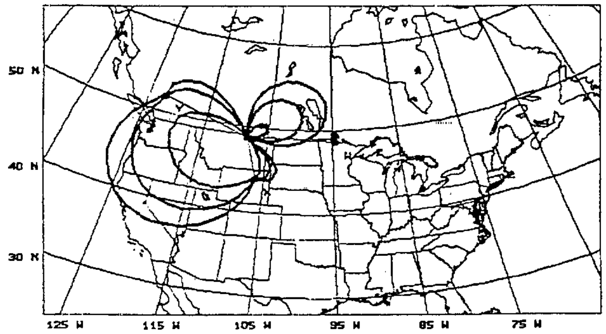
40 N
30 N
20 N
105 W
95 W
85 W
75 W
65 W
X
Z

MXZ

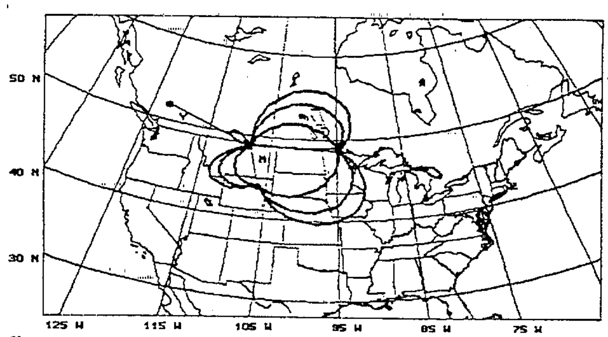


40 N
30 N
20 N
105 W
95 W
85 W
75 W
65 W
X

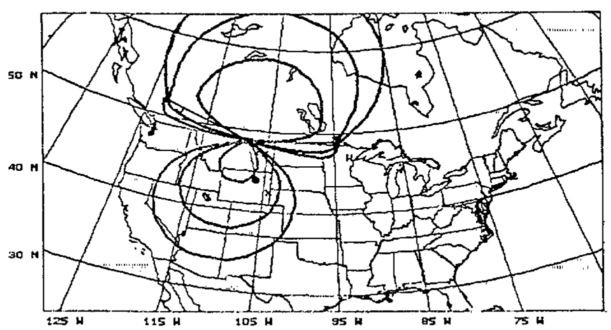
MYZ


50 N
40 N
30 N
125 W
115 W
105 W
95 W
85 W
75 W

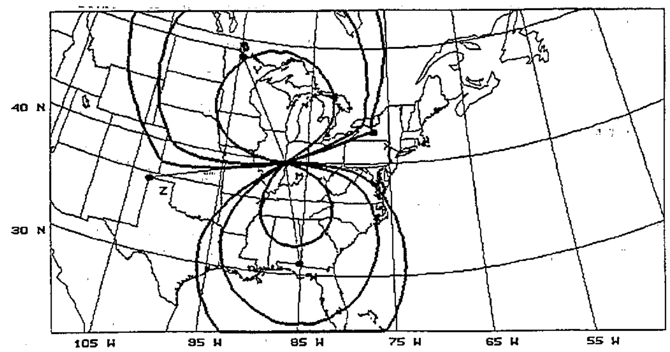
MXY


50 N
40 N
30 N
125 W
115 W
105 W
95 W
85 W
75 W

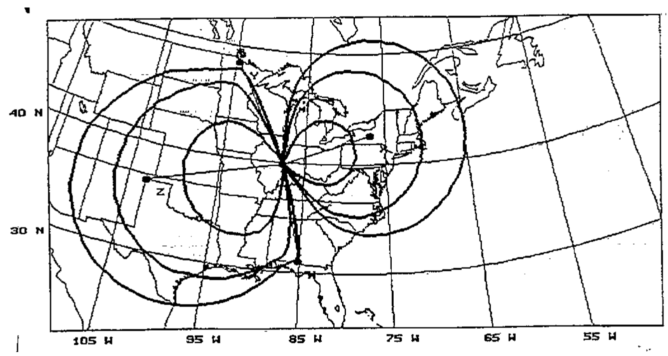
MWX


50 N
40 N
30 N
125 W
115 W
105 W
95 W
85 W
75 W

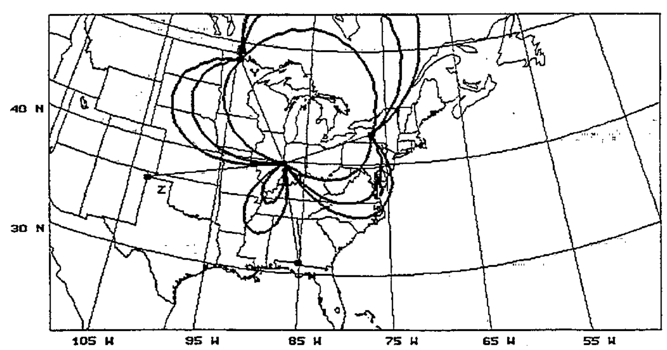
MWY


40 N
30 N
105 W
95 W
85 W
75 W
65 W
55 W
Z

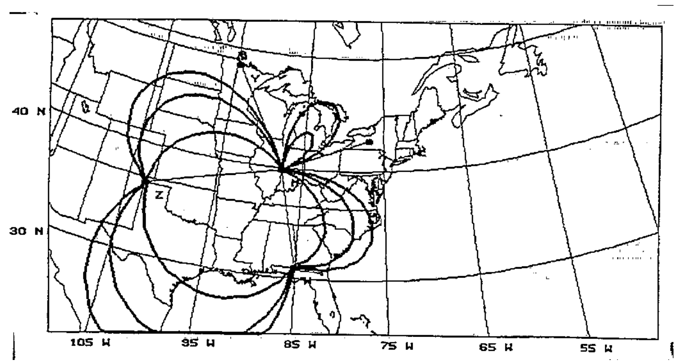
MXZ


40 N
30 N
105 W
95 W
85 W
75 W
65 W
55 W
Z

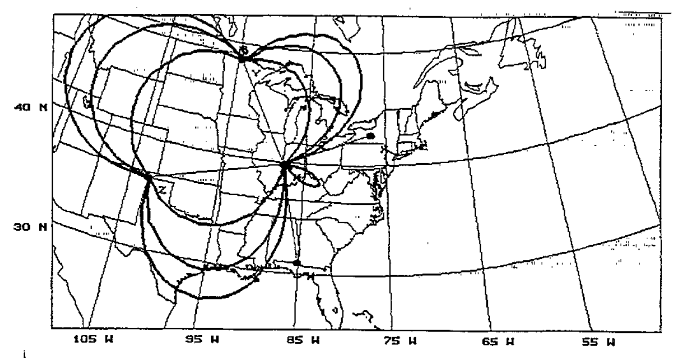
MWY


40 N
30 N
105 W
95 W
85 W
75 W
65 W
55 W
Z

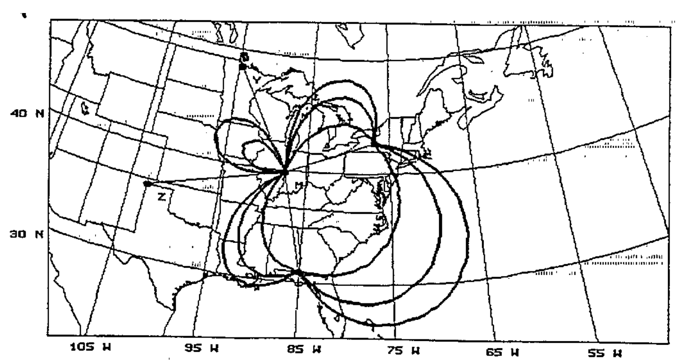
MXY


40 N
30 N
105 W
95 W
85 W
75 W
65 W
55 W

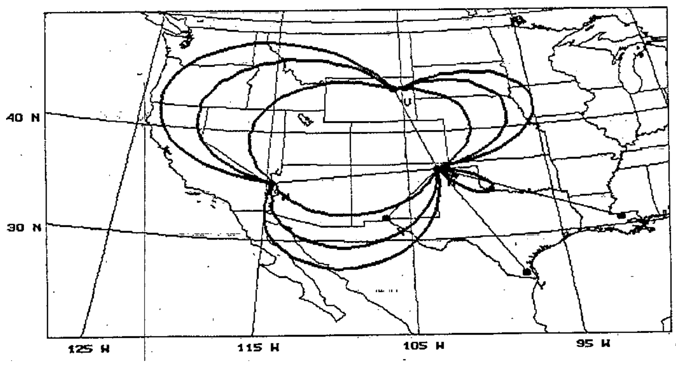
MWZ


40 N
30 N
105 W
95 W
85 W
75 W
65 W
55 W

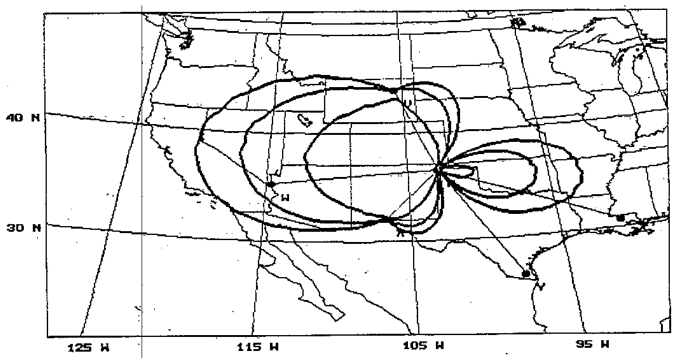
MYZ


40 N
30 N
105 W
95 W
85 W
75 W
65 W
55 W

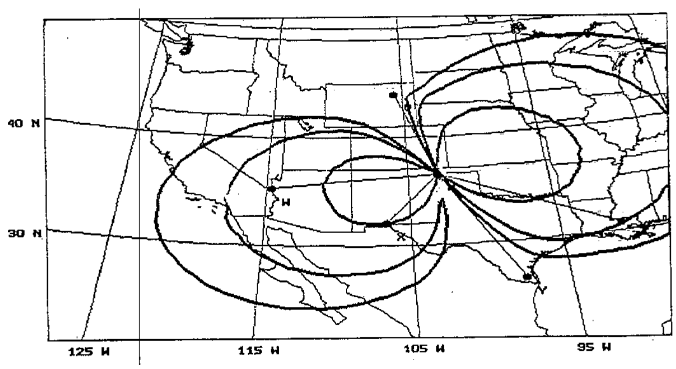
MWX


40 N
30 N
125 W
115 W
105 W
95 W

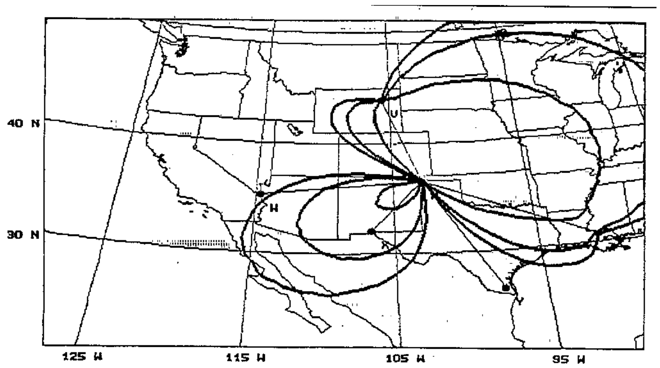
MWV


40 N
30 N
125 W
115 W
105 W
95 W

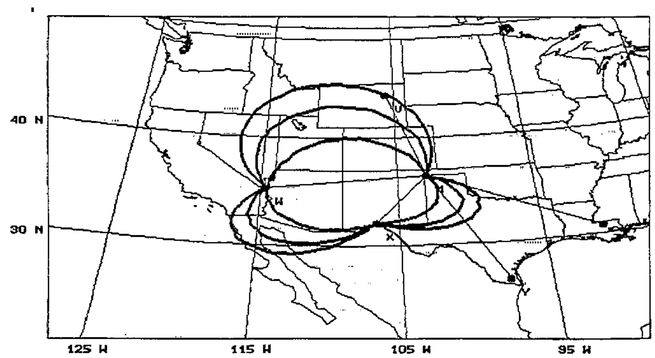
MXV


40 N
30 N
125 W
115 W
105 W
95 W

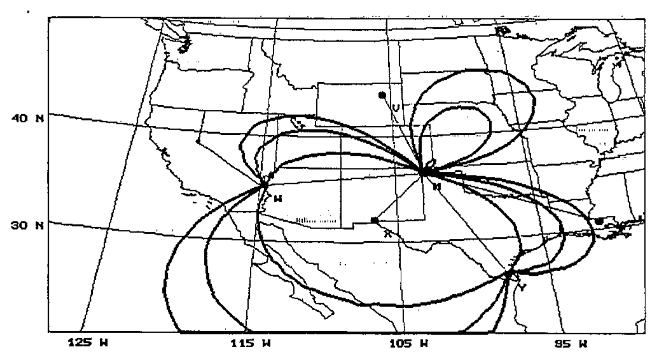
MVY


40 N
30 N
125 W
115 W
105 W
95 W
U
W
X
Y

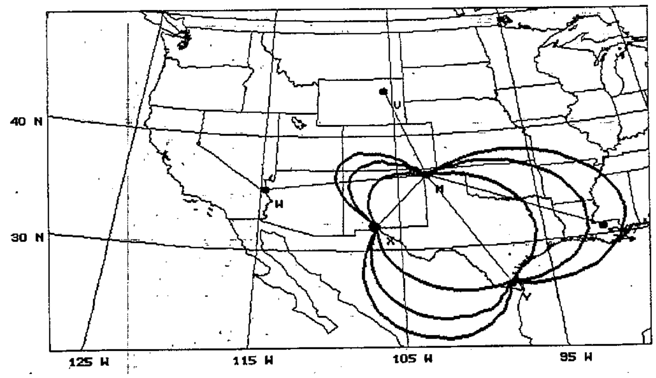
MZV


40 N
30 N
125 W
115 W
105 W
95 W
U
W
X

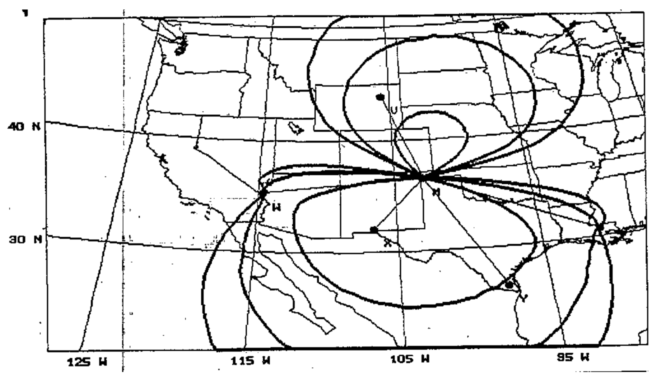
MWX


40 N
30 N
125 W
115 W
105 W
95 W
U
W
X
Y

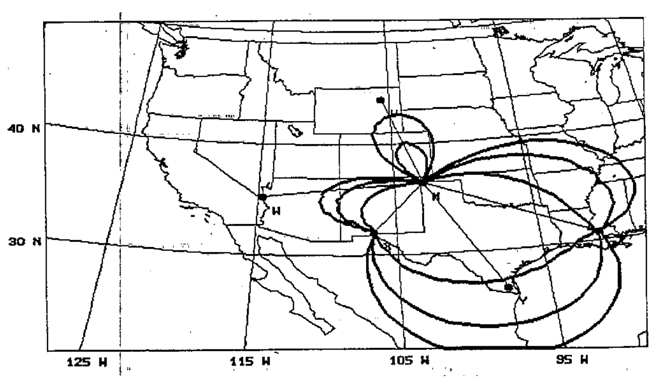
MWY


40 N
30 N
125 W
115 W
105 W
95 W
U
W
X
Y

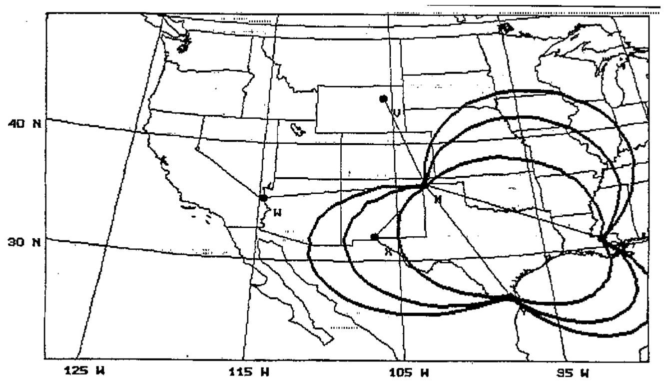
MXY


40 N
30 N
125 W
115 W
105 W
95 W
U
W
X

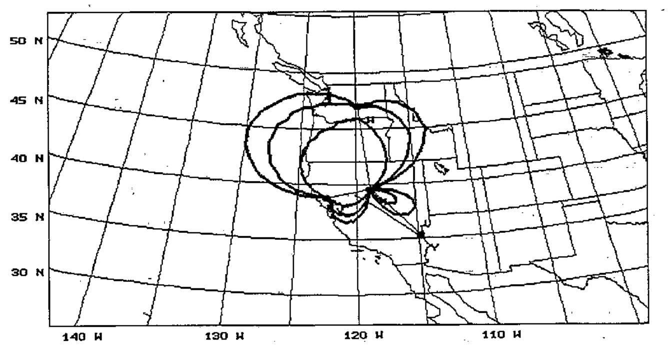
MWZ


40 N
30 N
125 W
115 W
105 W
95 W
W
Y

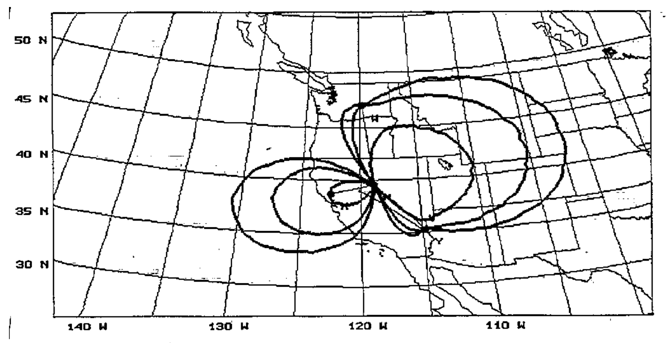
MXZ



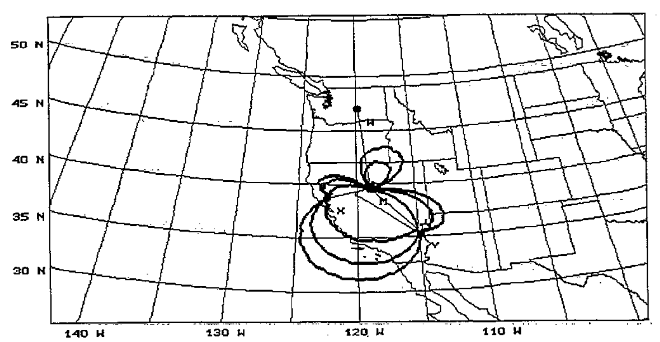
MYZ


50 N
45 N
40 N
35 N
30 N
140 W
130 W
120 W
110 W
W
Y

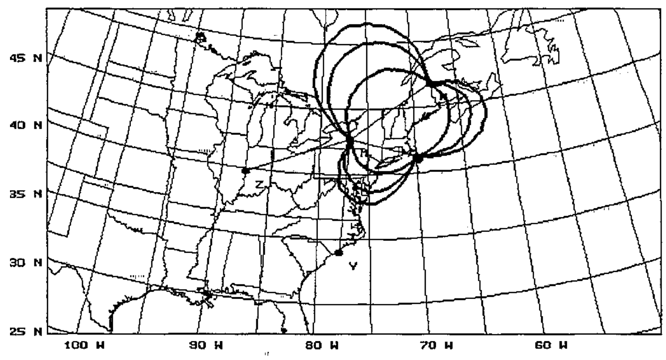
MWY


50 N
45 N
40 N
35 N
30 N
140 W
130 W
120 W
110 W
W

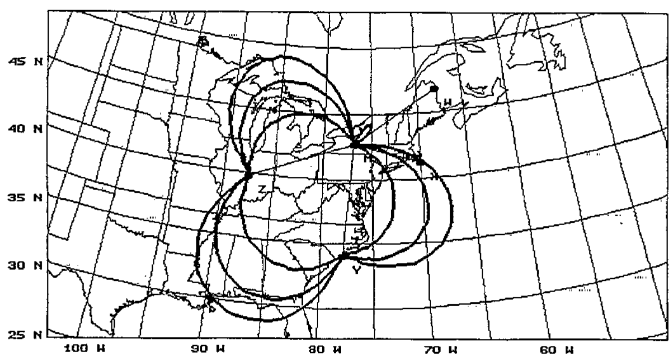
MWY


50 N
45 N
40 N
35 N
30 N
140 W
130 W
120 W
110 W
W
X
M
Y

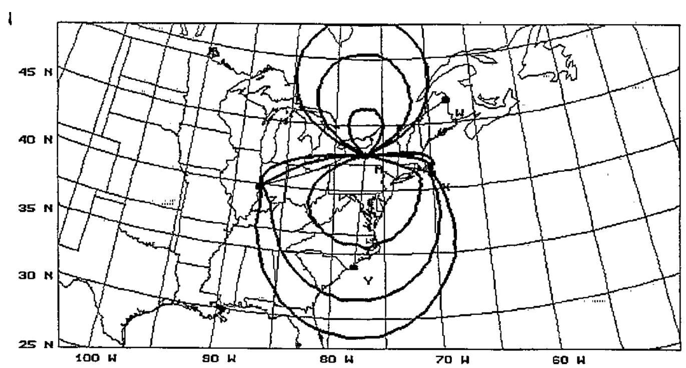
MXY


45 N
40 N
35 N
30 N
25 N
100 W
90 W
80 W
70 W
60 W
Z
Y

MWX

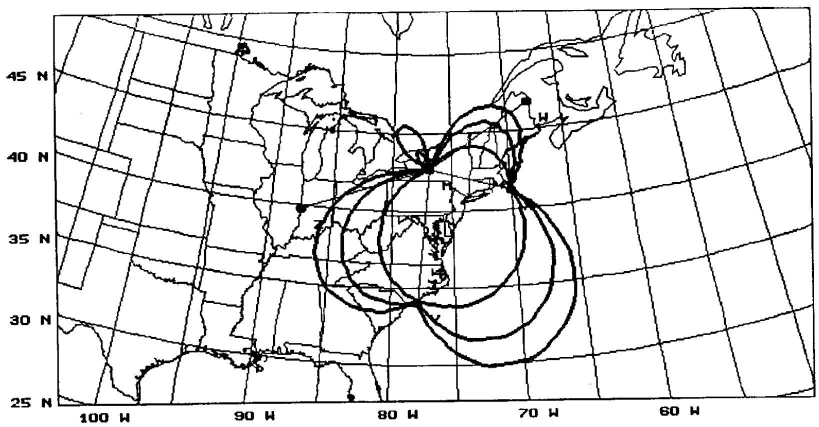

45 N
40 N
35 N
30 N
25 N
100 W
90 W
80 W
70 W
60 W
W
M
Z
Y

MYZ


45 N
40 N
35 N
30 N
25 N
100 W
90 W
80 W
70 W
60 W
W
M
X
Z
Y

MXZ

LORAN-C GRI 9960
NORTHEAST U.S. CHAIN (NEUS) (cont'd.)

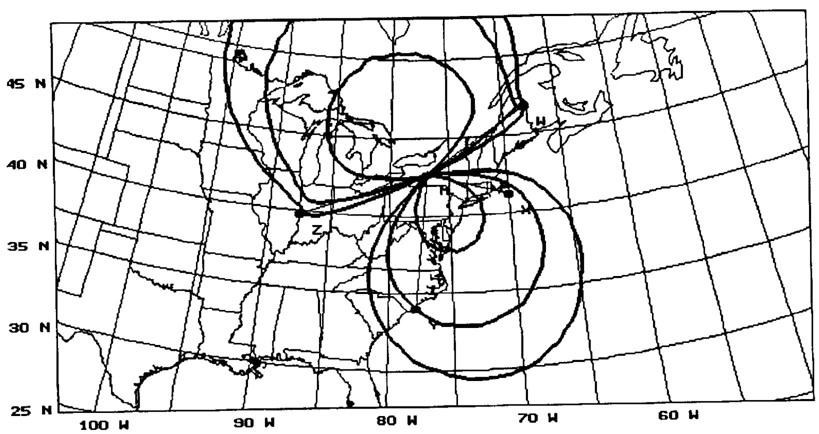


MXY

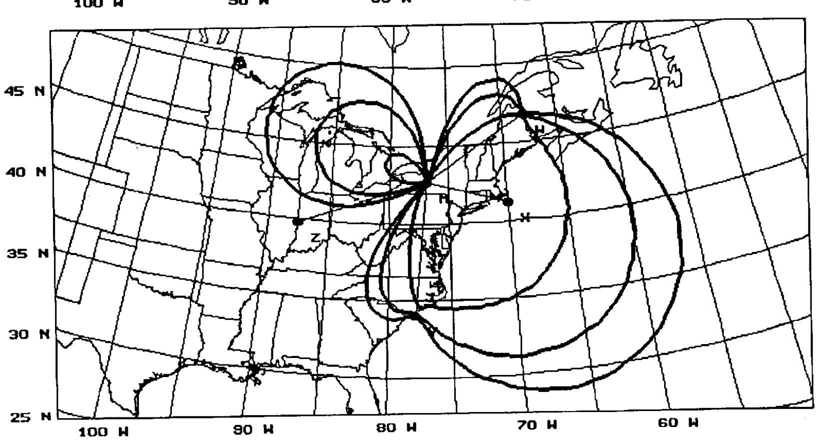
2 drms Fix Accuracy
with σ = 0.1 *us*

Inner curve -500 ft.
Middle curve-1000 ft.
Outer curve -1500 ft.

Note: These contours are based on geometry only, and do not include range limits.

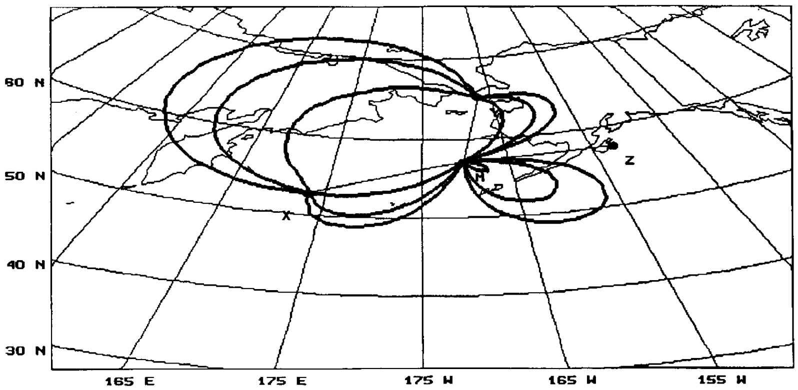


MWZ



MWY

LORAN-C GRI 9990
NORTH PACIFIC CHAIN (NORPAC)

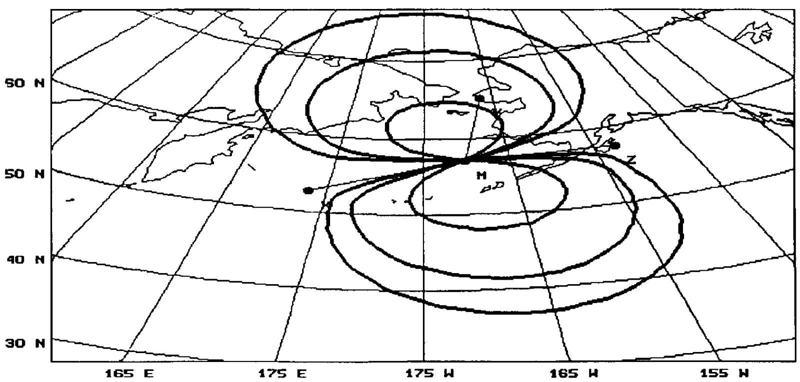


MXY

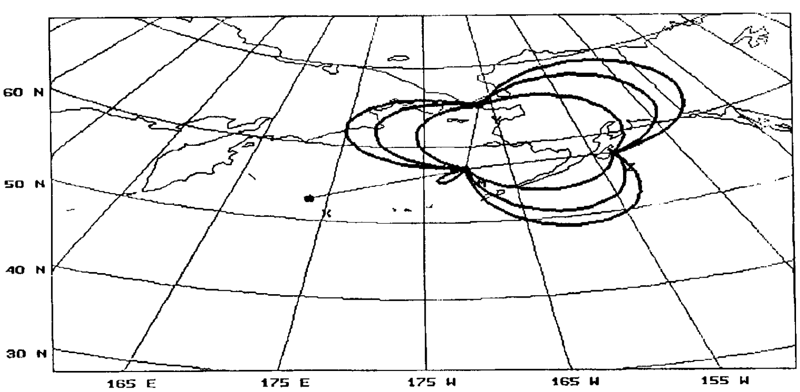
2 drms Fix Accuracy
with σ = 0.1 *us*

Inner curve -500 ft.
Middle curve-1000 ft.
Outer curve -1500 ft.

Note: These contours are based on geometry only, and do not include range limits.



MXZ



MYZ

)

APPENDIX D
LORAN-C PROGRAM ADDRESSES AND PHONE NUMBERS

PROGRAM MANAGER

Commandant (G-NRN)
U.S. Coast Guard
2100 Second St. S.W.
Washington D-C. 20593-0001
Phone: (262) 267-0283
Fax: (202) 267-4427

NAVIGATION CENTER (NAVCEN)

Commanding Officer
U.S. Coast Guard NAVCEN
7323 Telegraph Rd.
Alexandra, VA 22310-3998
Phone:(703) 313-5800
Fax:(703) 313-5805/5920

NAVIGATION INFORMATION CENTER
(Staffed 24 Hrs/Day)
Commanding Officer
U.S. Coast Guard NAVCEN
7323 Telegraph Road Alexandria,
VA 22310-3998
Recording:(703) 313-5905
Watch Phone:(703) 313-5900
Fax:(703) 313-5920

ENGINEERING CENTER

Commanding Officer
USCG Electronics Engineering Ctr
P.O. Box 60
Wildwood, NJ 08260-0060
Phone: (609) 523-7271

LORAN-C REGIONAL MANAGERS

Commanding Officer
USCG NAVCEN West Coast Operations
C/o USCG TRACEN Petaluma
Petaluma, CA 94952-5000
Phone: Not yet established
Fax: at time of printing.

Manages the following chains:
9990/9940/8290/7960/5990/5980

Commanding Officer
USCG NAVCEN
7323 Telegraph Rd
Alexandria, VA 22310-3998
Phone: (763) 313-5870
Fax: (703) 313-5805/5920

Manages the following chains:
9960/9610/8970/7980/7930/5930

COORDINATOR OF CHAIN OPERATIONS (COCO)

COCO NEUS 9960/GLKS 8970:

Coordinator Of Chain Operations
USCG Loran Station Seneca
P.O. Box 28
Romulus, NY 14541-0028
Phone: (607) 869-1334

COCO SEUS 7980/SOCUS 9610:

Coordinator Of Chain Operations
USCG Loran Station Malone
P.O. Box 387
Malone, FL 32445-0387
Phone: (205) 899-5225

COCO USWC 9940/NOCUS 8290:

Coordinator Of Chain Operations
USCG Loran Station
Middletown, CA 95461-9999
Phone: (707) 987-2911

COCO GOA 7960/NORPAC 9990/ COLO RAC 5980:

Coordinator Of Chain Operations
USCG Loran Station Kodiak
P.O. Box 190032
Kodiak, AK 99619-0032
Phone: (907) 487-5183

COCO CWC Chain 5990:

Coordinator Of Chain Operations
Canadian Coast Guard (FMTMC)
Rm 411 100 Park Royal South
West Vancouver, BC V7T 1A2
Canada
Phone: (604) 666-0472

COCO CEC Chain 5930/NFLD Chain:

Coordinator Of Chain Operations
Canadian Coast Guard
Box 693
St Anthony, NF AOK 4WO
Canada
Phone: (709) 454-2392

This page intentionally left blank.